POWER PLANT ENGINEERING

GENERATION - TRANSMISSION - DISTRIBUTION - UTILIZATION

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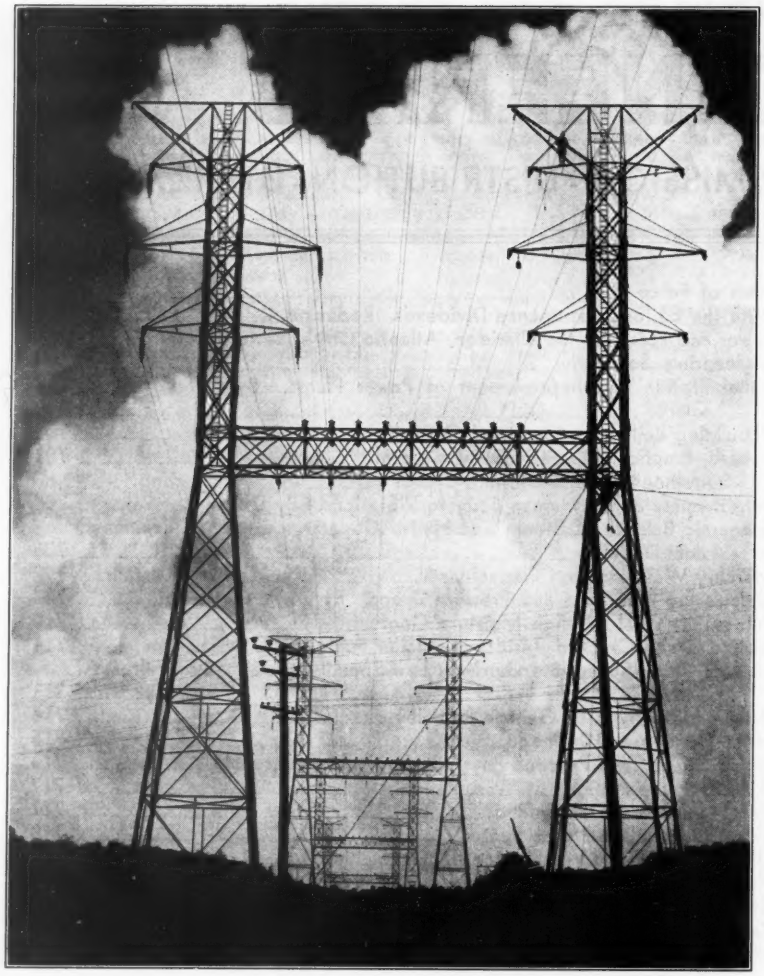


Lines of Force

STRETCHING OUTWARD, across the sky of a lazy summer afternoon, these "lines of force," more than any other of the works of man, symbolize the age of electricity. They represent man's conquest over the most mysterious and powerful of all forces in nature. By their means, the once awesome force of electricity inherent in the billowy clouds overhead, is kept in submission and made to serve the needs and comforts of mankind. Silent, motionless, impressive, these tower lines stand as sentinels guarding the highways of electricity to our homes and factories.

Less tangible but more mysterious are the invisible lines of force which surround the conductors on these towers and which have caused electrical engineers to become gray before their time. For it is the unseen lines of force that really challenge the electrical engineers' skill and ability. Indeed it is not in the conductor itself, but in the space surrounding the conductors that the force of electricity resides and it is upon an exact knowledge of what happens in this space that our successful control and application of the electric force depends. Take for example the time worn subject of power factor. Every engineer who has ever had anything to do with alternating current circuits has at some time or other wrinkled his brow and puzzled over the mysterious cosine phi which denotes power factor. And even after he has learned to deal with it quantitatively, he is not always clear as to just what it means in the circuit, for this, among many others, is a manifestation of the elusive lines of electric and magnetic force we have been discussing.

Because of this, the discussion of power factor between the "old timer" and the skeptical chemist beginning on page 718 of this issue should be of general interest. Though not always dignified, this discussion is bound to clear up a number of hazy points. The young chemist will take nothing for granted and before he gets through he will make the chief explain all.

Tracking the Whirl to Its Last Spin

Did you ever, when paddling a canoe, watch the whirls and eddys set up by the paddle wiggle down stream? Did you ever stop to wonder what became of them—where they went? No? Well, neither have we, but John S. Carpenter it appears took these whirls rather seriously and so one night, with a dark lantern in one hand and a police whistle in the other, he set out on their trail. And where do you suppose they went? Right smack into the "works" of a hydraulic turbine and then, not content with a ride on the "merry-go-round," they performed tail spins on the runner surfaces. Being a true disciple of Sherlock Homes, Mr. Carpenter always carries a microscope in his vest pocket and in looking for finger prints, he found a hole wherever there had been a whirl.

Now this is a thing no good hydraulic engineer will tolerate and Mr. Carpenter, being an even better hydraulic engineer than he is a detective (indeed, being a detective is only a hobby), went back home and devised a mathematical formula with which to trap the hydraulic whirls. This is given on page 727 where Mr. Carpenter presents a full account of his findings.

As Easy as Falling Off a Log

With a chart such as presented on page 708 by G. A. Gaffert, the design of a steam piping job becomes as easy as the proverbial falling off a log. Ordinarily, in the design of piping systems, many hours are spent in computing internal pipe areas, friction coefficients and a lot of other things. Mr. Gaffert used to do a great deal of this and one day his slide rule got so hot he had to stop to let it cool off. While waiting he decided to end the matter once and for always by making a chart. In our opinion it is one of the best we have ever seen.

WITH THE EDITORS

Experience Dividends

EXPERIENCE is difficult to classify. To a certain extent it is a commodity that can be bought, sold or bartered yet it is practically impossible to evaluate. One interested in building say, a new power plant, can go out and buy the services of an experienced engineer or group of engineers, paying in the form of wages.

Again the fundamental basis of all engineering societies is barter—the trading of experiences, the giving of experiences to a common fund of knowledge for the advancement of the profession or humanity and no doubt the selfish, but quite human, feeling that when the time comes the experience of others can be drawn from the same fund and utilized.

Unfortunately, neither of these methods is available to the leaders in any line. They must learn by practice, building the mistakes of today into solid foundations of tomorrow. This has been largely true in the power plant where each year sees a substantial advance over the year before. This advance may be described as cantilever construction with a beam of intelligence and common sense extended from the foundation of past experience.

Too often, however, the foundation of past experience is not used because the tie-up between the operating department and designing department is not sufficiently close. In these changing days, a plant must of necessity be somewhat of an experimental laboratory and as such it is extremely difficult if not impossible to distribute costs properly.

In one station that has been a leader for a decade, such development work has never ceased and it is reported that work done there saved $1,000,000 in the construction of a new plant. It is impossible to look back at experimental expenses and say "this dollar expended returned five or this change gave us data which reduced future expenditures $100,000 or this three weeks' investigation kept us from sinking $50,000 in an impractical scheme."

Good power plant design calls for a one horse shay construction with each part as strong as the other. Unfortunately this ideal has not been adhered to in the past, with the result that some parts of the plant have been made inordinately strong with a corresponding increase in capital cost. A few companies are proceeding on a well-planned course making use of the experience purchased at the expense of numerous trials. We all purchase this experience dearly but only the intelligent ones make it pay dividends.

Reducing

EXERCISING, both voluntary and mechanically produced, diets from 6-day to 6-month, mental attitudes either solo or as auxiliary to the other two, have been much advocated and in evidence to reduce swollen busts, hips, abdomens and calves so as to conform to popular standards. It would seem that a like procedure on the part of government bodies would be highly popular.

Four principles of the Taxpayers' League, recently laid down by former senator James W. Wadsworth are: "Immediate reduction of 25 per cent in the operating cost of government. Withdrawal of government from competition with private business. Abolition of all governmental activities not essentially governmental. Cessation of Federal aid to enterprises not strictly federal in nature."

Perhaps the first step essential to reduction is the will to reduce and this must be injected into political bodies by the action of such organizations as the Taxpayers' League and by the will of voters at elections. Politicians, office holders and job holders are prone to be quite content with the "pleasing plumpness" now existing in government expenditures, activities and pay rolls. But taxpayers, which in effect includes everybody who spends money or pays bills, are paying exorbitantly for this "plumpness," which, to the outside observer strongly resembles big double chins, distended "bay windows" and elephantine legs.

Investigations now in progress have shown that Federal bureaus and departments are in direct competition with more than 160 industries, in some cases to the destruction of private business. Army and Navy commissaries which sell to the public, government printing of envelopes and business post cards, the attempt at post office cafeterias are examples.

Paternalistic and maternalistic activities of bureaus in the Departments of Commerce and of Agriculture would, from the amounts expended and the number of publications sent out seem to be too well known to need comment.

Pork-barrel Federal aid is so well recognized in Washington that the only limit has been what the "traffic would bear."

Inefficient or useless political and family appointees are evident in offices of every branch of Federal, state and municipal government. To discover and weed them out will be difficult but is part of the job.

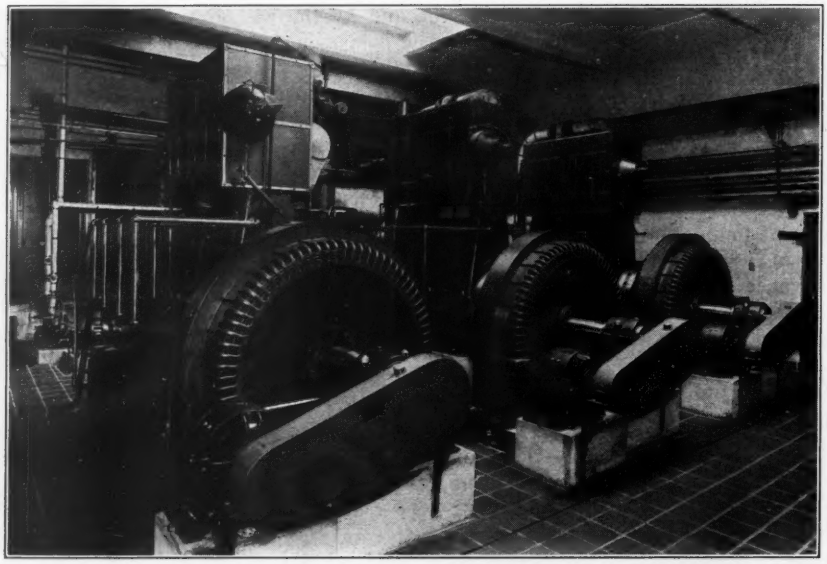
As in the case of individuals, reducing of government excess loading involves will power, time to get results and ceaseless vigilance to reach and maintain reduction to such a condition that efficient activity will be secured. The important question is whether we, as citizens whose interests are at stake, have the intelligence, the vigilance and the persistence to get from those who ostensibly represent and are employed by us the kind of service required, if government is to be reduced to an effective and economical basis.

Neither a single emotional effort nor chasing of rainbows painted by demagogical political orators will do it. The same continued attention and careful study will be needed that are necessary to the successful conduct of any business by its owners.

CONSTRUCTION of 330,000 mi. of service lines to supply power to farms at a cost of $500,000,000 and creating a market for $1,000,000,000 worth of machinery and appliances for farm use is an achievement planned for the near future. Farm work will be done at lower cost and with easier conditions; farm life will be pleasanter and utilities will have a worth-while addition to their domestic load, which has proved a life saver for them as industrial demand has decreased.

POWER PLANT ENGINEERING October 1932

Power and Heat *for the* *CLARIDGE*, Atlantic City's N



AMONG THE MANY HOTELS which make Atlantic City the world-famous resort that it is, the newest and one of the finest in its service and appointments is the new Claridge at Indiana Ave., Park Place and the ocean. Because of its multitudinous water, heat and power requirements, a large hotel always presents features of interest to power plant engineers and usually a hotel has its own generating plant. In this respect the Claridge is no exception; it is provided with a well designed power plant furnishing steam, hot water and electricity to the entire institution. Each of its 430 large guest rooms is equipped with bath and shower, hot and cold, salt and fresh running water. For fresh water, the plant has its own artesian well, 840 ft. deep.

This power plant is located on the ground floor of the building, that is the boilers, generating units and the refrigerating machinery. The pumps and hot water generators are located on the floor below. The boilers really occupy two floors, the firing floor being in the basement, as shown by the accompanying drawings.

Compact Arrangement of Equipment Reduces Fixed Charges

In any large hotel floor space is at a premium and so it is desirable that the space occupied by the power equipment be as small as possible, consistent, of course, with the requirements for good operation. This feature has received particular attention at the Claridge and though the power plant is compactly arranged, there is sufficient room for convenient operation of equipment.

Steam is generated in three Edge Moor water tube boilers, rated at 200 hp. each. These are three pass units built for a working pressure of 175 lb. and fired by McClave Brooks hand stokers burning anthracite rice coal and arranged for forced draft operation. The latter is supplied by an American Blower Co. fan arranged for combination motor and steam drive, a 15 hp. G.E. induction motor being attached to one end of the shaft and a 6 by 6 in. noncondensing steam engine to the opposite end. The motor drive is through a reduction gear having a ratio of 1700 to 350 r.p.m.

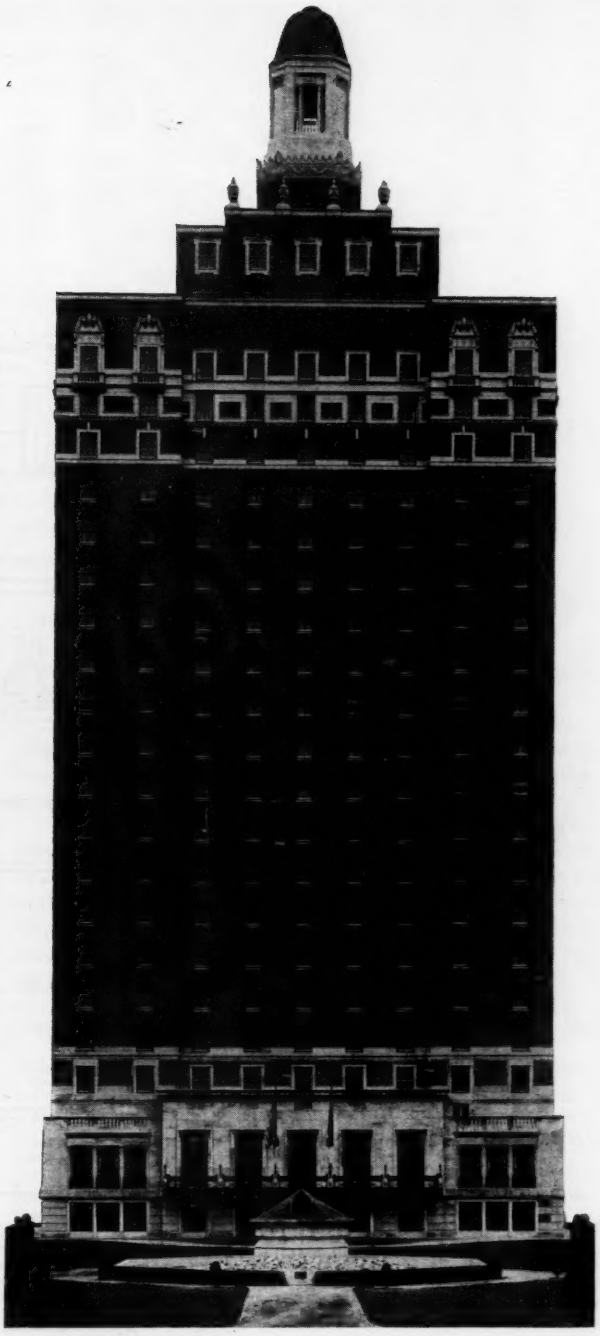
Draft over the fire is induced by a stack 380 ft. high running up through the 24-story building. This stack is 54 in. in diameter at the 24th floor and furnishes more than ample draft for combustion even under the heaviest loads. Automatic damper control is provided. The forced draft fan, as may be noted from the drawings, is located at one end of the boiler room and feeds into a forced draft duct running underneath the rear of the boilers. The uptake connections are on the tops of the boilers at the rear. These connect into a common duct at the rear of the boilers and are delivered to the stack as shown in the diagram.

At present coal is delivered to the stoker hoppers by hand although in the future an arrangement will be worked out whereby the coal will be delivered through chutes directly from overhead coal bunkers. Now, the coal is delivered by truck directly to the coal storage bunkers in front of the boilers, from which it is shoveled into the stoker hoppers.

The ash handling system is slightly more elaborate. This, as may be noted from the elevation in Fig. 3, is hoed into the receiving hopper of a motor driven bucket elevator which delivers it to a steel ash bunker above the driveway. This ash bunker is entirely enclosed so as to eliminate dust, an extremely important requirement in a installation of this kind.

Boilers are provided with the usual accessories, Reliance gage columns, Vulcan soot blowers, Yarway blow-off valves, Ashcroft safety valves and Copes feed water regulators. The furnaces are of a good grade of fire

y's Newest Hotel



brick laid in high temperature cement. A full set of indicating and recording pressure and temperature gages is provided for measuring all steam and water. These, which are all Foxboro instruments are conveniently located on a panel board in the engine room.

Feed water is derived from the main deep well supply. This is exceedingly pure, testing about 99 per cent pure, consequently no feed water treatment is necessary. A small amount of sal soda is added from time to time to keep the water alkaline. The feed water is heated to a temperature of approximately 208 deg. F. in a Cochrane open heater and is delivered to the boilers by a Warren simplex steam pump, 7½ by 5½ by 10 in. The amount of make-up required is relatively small, since all condensate from the hot water generators, steam tables, laundry, etc., as well as the heating system is returned to the boilers.

Electric Generating Equipment

It is in the engine room that the real compactness of this power plant is most evident. There are three generator units, consisting of Ames 4-cylinder, vertical steam engines direct connected to 200-kw. General Electric Co. a.c. generators, operating at 400 r.p.m. Current is generated at 220 v. and it is distributed throughout the hotel at that voltage for all power purposes. For lighting, however, 110 v. is used, current at this voltage being supplied by 2 sets of 220/110 v. step down transformers located near the boiler room.

Each generator is provided with its own exciter mounted on the generator foundation and connected to the generator shaft by an enclosed chain drive.

The engines, of course, operate non-condensing. Normal operating conditions call for 175 lb. steam pressure at the throttle and 3 lb. gage exhaust pressure.

These three engines, as may be noted from the photograph, occupy an extremely small space, yet there is ample room around them for convenient operation. The room is provided with a hand operated crane for handling the machinery in case of repair or overhauling.

Refrigerating Equipment

In addition to the three generating units, the engine room contains three ammonia compressors for refrigeration service, together with certain auxiliary equipment such as ice water pumps and ice water tank. All three of the compressors are made by the Frick Co. Two are 7 by 7 in. machines, of about 16 tons capacity; the third machine is a small unit of about 3 tons capacity used for hardening. The large compressors are driven through V-belt drive by 30 hp. G.E. induction motors. The small machine is similarly driven by a 2½ hp. motor.

Brine is circulated to the kitchen and cafeteria and an ice tank is provided having a capacity of 4 tons of ice per 24 hrs. Two brine pumps driven by 7½ hp. motors provide brine circulation.

Pumping Equipment

With the exception of the ice water pumps which are installed in the engine room, all pumps are located in the basement, together with the water storage tanks and hot water generators. The arrangement is as shown in Fig. 4. All steam pumps are Warren Steam Pump Co. units. A list of the principal units together with their sizes follows:

2 Low zone pumps, duplex, 12 by 10 by 12 in.
2 High zone pumps, duplex, 12 by 8½ by 12 in.

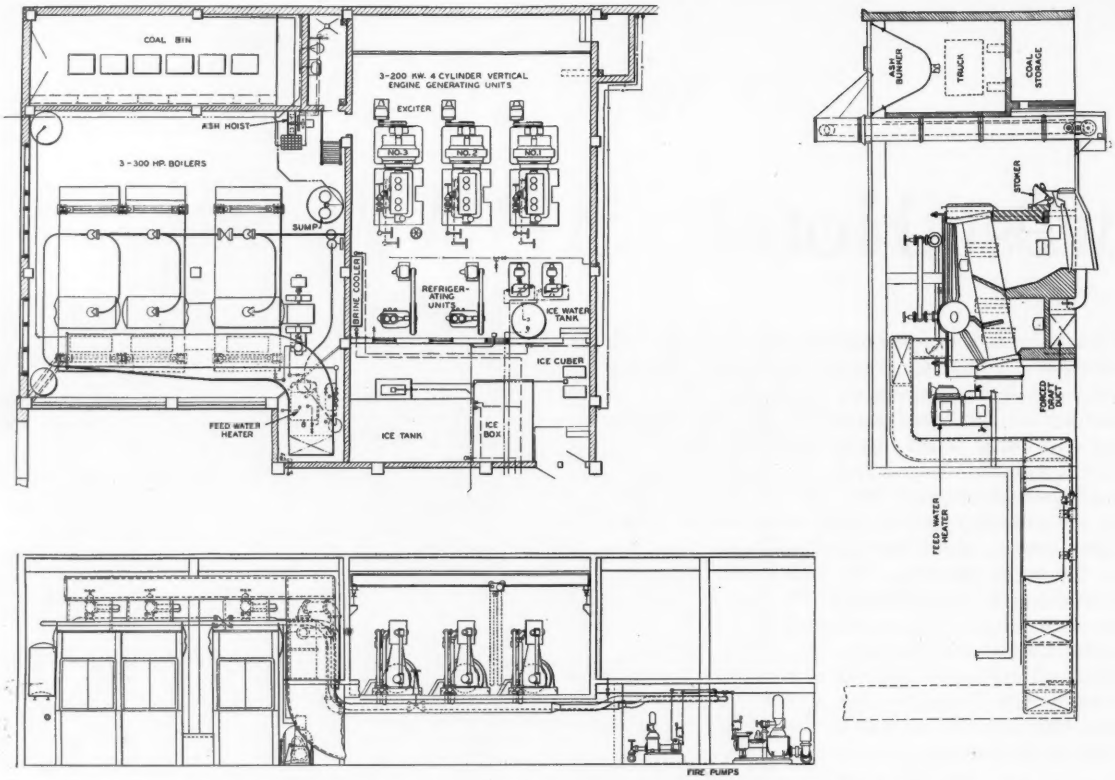


FIG. 3. PLAN AND ELEVATION OF THE BOILER AND ENGINE ROOM AT THE CLARIDGE.

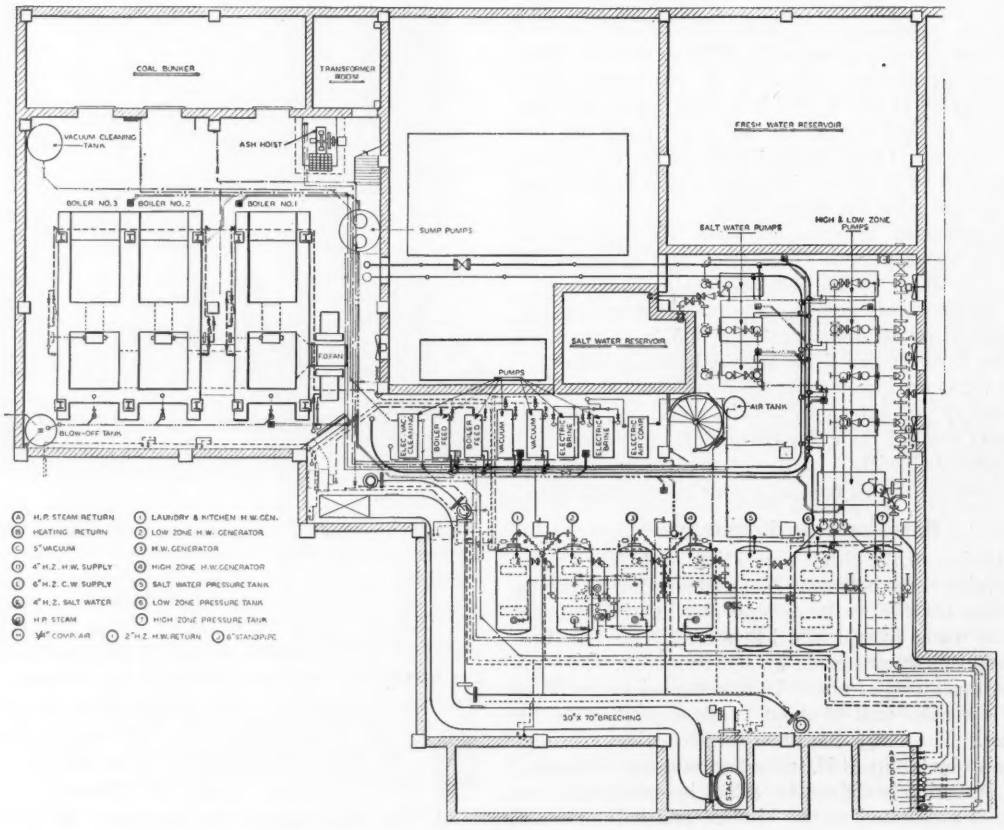


FIG. 4. ARRANGEMENT OF EQUIPMENT IN THE PUMP ROOMS.

1 Main fire pump, duplex, 16 by 9 by 12 in.
2 High and low zone, salt water, duplex, 10 by 6 by 12 in.
1 Sea water pump, duplex, 5 by 5½ by 6 in.
2 Vacuum pumps, single acting, 8 by 12 by 12 in.
2 Boiler feed pumps, duplex, 5½ by 5 by 10 in.
2 Brine circulating centrifugal, motor driven pumps.
1 Aerating pump for ice making.
2 Motor driven sump pumps.

In addition to this equipment there is also installed in the basement—

2 Air compressors, one small Curtis unit for laundry service and one 5 by 9 by 3 in. Ingersol Rand unit for general service. Both are motor driven.

1 Allen air vacuum unit, driven by a 15 hp. induction motor.

4 Hot water generators 52 in. by 9 ft. made by the Whitlock Coil Pipe Co.

3 Cold water pressure storage tanks for cold fresh and salt water.

A two zone system is used at the Claridge, that is, everything below the tenth floor constitutes the low zone and everything above the 10th floor the high zone.

Heating and Hot Water Systems

From the engine room a 12 in. exhaust line passes through the basement with a connection to the hot water generators which are thermostatically controlled to maintain 180 deg. water temperature, thence up through the center of the building to the pipe loft on the 22nd floor, here it branches off and makes a complete circle of this floor, with legs and risers passing up and down, thus providing a complete system of vapor distribution. The 12 in. exhaust line to the roof is provided with a 12-in. Cochrane regulating valve which in cold weather is set at 5 lb. At times when no heating service is required, however, this setting is reduced to 2½ lb. to lower the back pressure on the engines and pumps. Thus all heat, for buildings, hot water service and heat in the boiler feed water is obtained from exhaust steam.

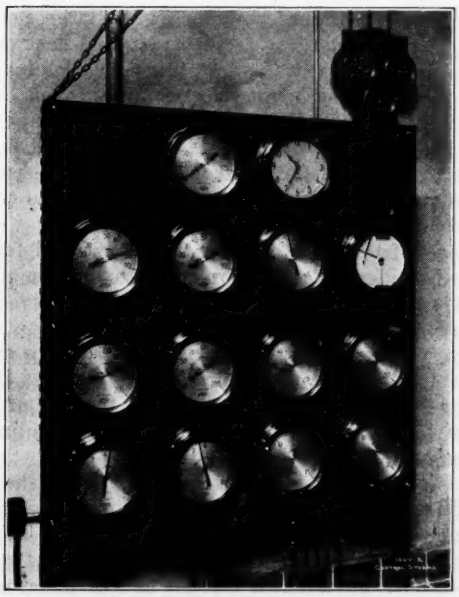


FIG. 5. METER PANEL IN THE ENGINE ROOM.

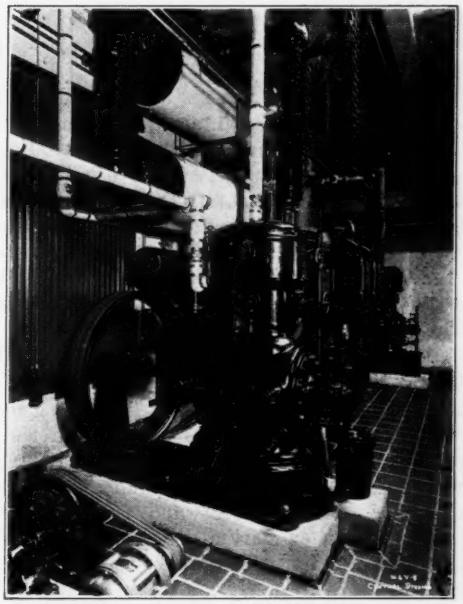


FIG. 6. THE TWO LARGE REFRIGERATING MACHINES.

The vacuum pumps maintain from 5 to 8 in. of vacuum at all times.

Steam, both high pressure and exhaust, is also supplied to the laundry and kitchen. In the bakery there are installed two electric ovens, each of 16½ kw. capacity as well as motor driven dough and cake mixers.

Elevators are 5 in number, with two hoists. The elevators are the Gurney type, 700 ft. per min, with Waggoner automatic signal control. Each motor generator set takes up to 78 kw. on starting. The acceleration is from dead stop to full speed in 4 seconds. Each elevator has 8 speeds and requires from 30 to 60 hp. on starting.

TABLE. FIGURES SHOWING OPERATION OF THE PLANT DURING TYPICAL SUMMER AND WINTER MONTHS.

	August 1931	March 1932
Total power generated, kw-hr.	92,308	60,934
Lowest load, kw.	80	35
Highest load, kw.	335	310
Average load (over period of 31 days), kw.	124	81.9
Total fresh water pumped, gal.	5,706,300	3,076,700
Water reclaimed from circulation, gal.	3,624,300	1,961,700
Fresh water used, gal.	2,082,000	1,115,000
Hot water used, gal.	578,000	289,650
Ice pulled, lb.	114,000	55,800
Water evaporated, lb.	7,152,340	5,873,360
Average lb. water evaporated per lb. of coal	10.3	10.3
Average boiler horsepower	320	263
Coal used per day, tons	10	8.22
Average feed water temperature, deg. F.	208	208

Operation

To give the results of operating this plant, the operating data for two months of the year is shown in the accompanying tabulation. One set of figures is for the month of August when the demand for heat is relatively low and the other for March when the heat demand is considerable.

The uniformity in the rate of evaporation is to be noted. A plant of this type operates efficiently because the heat in the exhaust can be utilized to advantage at all times. Steam is used in a multiude of different operations. In the kitchen live steam at 35 lb. pressure

is used on steam cookers, egg cookers, coffee urns, soup pots and steam tables; 90 lb. steam is used in the laundry.

Well water pumped averages about 58 deg. F.; the hot water generators are maintained at from 175 to 180 deg. So to raise the temperature of 289,600 gal. of water as shown for the month of March, 60 to 180 deg. requires some 278,064,000 B.t.u. All this, plus the heat used in heating the building and that required to heat the boiler feed water is obtained from the exhaust steam. Since the temperature of the returns is about 170 deg. the exhaust raises the boiler feed water 38 deg. in temperature. If electric power were purchased, practically as much coal would be required as is used with the present arrangement.

The Claridge was opened under the management of Roscoe J. Tompkins, well known in hotel circles and a man of wide experience, who died June 28 of this year and was succeeded by Robert Lander. Charles E. Chandler, the chief engineer and superintendent of maintenance, is an ex-marine man and is possessed of all the resourcefulness which which typifies the marine engineer. He was formerly associated with the Pacific Mail S. S. Co., the U. S. Lines and with various industrial plants in the vicinity of Philadelphia. We are indebted to him for the data and information contained in this article and also for the photographs and drawings.

Engineering Sociology

THAT DOESN'T REFER to the social instinct or the much heralded lack of it among engineers but to the conclusions of a committee of earnest-minded engineers from Missouri who have tried to determine and formulate how they and others may best meet the new conditions which have been set up in industry and society. Being from Missouri, they have had the "show me" spirit and have dealt with facts rather than theories and ideals, hence have arrived at practical suggestions instead of roseate, altruistic dreams.

In its report to American Engineering Council, the Missouri Committee of that body on Engineers and Employment submits the following points, which are put in abbreviated form since space available does not permit giving the complete and discerning analytic discussions of the original report.

Labor-saving machinery and efficient production methods, which nobody except communists wishes to scrap—and they only because they haven't yet learned how to copy those methods successfully—have brought us so far along the road pointed out by the late Dr. C. P. Steinmetz to production in shorter working weeks and possibly shorter working days of all we can use, leaving more time for recreation and cultural progress.

One means proposed for recreation and culture and for an "out" from industrial depression is the small farm as an opportunity for livelihood. Hard work, to be sure, but less strenuous than looking for an elusive job that doesn't exist. On the other hand, since more acreage is now cultivated than is needed to supply the wants of the country, why not reforest the least productive arable and all the waste land for the benefit of our descendants.

Some of the committee must be hunters and fishermen for one of their proposals is establishment of game and fishing preserves as recreation aids for the added leisure, expenses to be met in part from fishing and hunting licenses.

Depression Reserves

Looking at the inadequacy of resources of business organizations and individuals to tide over such a period as the present, and considering the predicament of foreign nations which have experimented with the unemployment dole, government regulative agencies are urged to foster and to make possible, by rates allowed for return on business, such conservation of funds as will be sufficient to bridge industrial hollows; also the adoption of plans to encourage and assist employes to make like provision for their own rainy days. Details of plans should be adapted to the conditions of firms and individuals but solution of the problem requires adequate and workable methods of setting up reserves in good times to carry over the inevitable bad times.

Reaching for the highest possible peak of production during prosperity is cited as a fundamental cause of overexpansion which results in assets that become frozen during depressions and must largely be written off as losses. To avoid this and to plan and prepare for work that will carry over depressions are functions of good management.

In engineering lines, plans for improvement, new designs of product, reconstruction of plant and reorganization of manufacturing processes are matters that may well be taken care of in periods of depression in preparation for the return of active demand for goods. Construction of public improvements may well be deferred to times when other work is lagging. This applies especially: To highways, both trunk routes and a cheaper type of paved feeder roads; to sanitary works for both water supply and sewage, although waterworks may well be left to private enterprise wherever that is possible; to buildings of public character such as colleges, libraries, galleries, museums and government structures.

Reduction of Government Overhead

Business-like responsibility in carrying out improvements is advocated, the council-manager method for city government being cited. Also consolidation of counties, whose governments are now one of our large causes of waste, is proposed, since facility of travel has removed the need for numerous county seats. This might well be supplemented by having most county officials, including county manager, appointed by the county court which should have control of all expenditure of moneys, by electing judges for longer terms and by replacing boards and commissions with individuals who will be responsible to the court for their actions.

Study of taxation to devise a scientific and fair system is considered essential in order to reform present abuses and injustices. Akin to this is the division of expense of constructing trafficways between state, county, village or city and fronting property owners, an example being a recent provision of Kansas City to bear on "trafficways" 50 per cent of the cost of right-of-way and 25 per cent of the cost of grading, all bridges and viaducts being built by the city.

This report is unique in its application of the methods of scientific engineering analysis to the solution of government and social problems and it will be interesting to watch the reactions and response of the politically-minded government officials and dividend-minded financial executives to the suggestions of the committee.

Rehabilitation and Improvement of Power Plants

Better Combustion, Heat Reclamation, Higher Pressures, Greater Thermal Efficiency and Output Are Results to be Sought.

By Charles W. E. Clarke*

REHABILITATE means "To restore to a former state, capacity, rank, etc." A well managed power plant is maintained as nearly as possible in its original "state, capacity, rank, etc.," but, even with the most complete and careful maintenance, equipment wears out and eventually must be renewed. The art advances and, when it becomes necessary to make major replacements due to the wearing out of the equipment, consideration should be given improvement of the plant by the use of new apparatus and methods, which will embody some of the improvements and economies that have become available since the plant was designed.

Principal factors that have contributed to improvement in the economy of power production within the last decade are:

(1) Increased knowledge of the fundamental principles of combustion which has resulted in better design of boiler furnaces and equipment for burning fuel.
(2) Understanding of heat reclamation devices such as air preheaters and economizers and the economic relations existing between the two, which decrease the loss due to heat rejected in the flue gases.
(3) Increase in the primary pressure and in the temperature or superheat of steam used for power production, resulting in an increase in the ratio of heat converted into work to total heat put into the steam in the boilers.
(4) Improvement in the design of prime movers so that their performance approaches more nearly the ideal and so that they can safely use the higher steam pressures and temperatures.
(5) Development of the binary cycle, notably the mercury vapor-steam cycle.

Efficiency Improvement

Improvements in design of equipment for steam production have resulted in raising the general efficiency of this process from a value approximating 70 per cent or perhaps less to one of 80 per cent or higher. The net result of all of these improvements is that the present day plant may have an overall thermal efficiency of nearly 25 per cent as compared with 15 per cent or less for the plants of a decade or more ago, a reduction of 40 per cent in fuel requirement.

What then can be done with plants built 10 to 15 yr. ago, which are still in good condition but of relatively poor economy? Usually, the savings possible through the installation of modern power apparatus are insufficient to justify scrapping equipment that is still in good running condition. In many cases, however, it is possible to secure material increases in the economy of old installations by replacement or modification of certain parts of the old equipment and the addition of modern elements.

Large central station companies whose sole business is the manufacture and sale of power are generally able to keep pace with available improvements in power plant efficiency. The growth of their business requires frequent construction of new power plants and such new installations, designed to embody the latest improvements in the art are used to carry the bulk of the load. Older and less efficient equipment is reserved for use mainly during peak periods and for standby.

The industrial plant is differently situated. Its growth may be rapid but is rarely of a magnitude that warrants construction of a series of complete new power units; hence, the policy of the industrial plant is usually to expand its power facilities along lines established in the original design. As a consequence, many industrial steam and power plants are inefficient and costly to operate, so that rehabilitation and improvement of existing steam and power plants is of particular interest to the industrial plant. Probably there is no industrial power plant, built more than 10 yr. ago, but can be improved in overall economy by the application of present-day knowledge in some form. The important consideration, however, and the one that is perhaps most often given inadequate analysis in connection with programs of rehabilitation and improvement of steam and power plants is the extent to which such improvements can profitably be carried. This question is usually harder to answer correctly in the industrial plant than in the central station.

In the central station the product is electrical energy and the load and its variations are known quite definitely. In the industrial plant the load is, in most cases, partly steam for processes and partly electrical energy. The most economical capacities and types of equipment in such instances are dependent not only on the loads but also upon their relation to each other and coincidence of occurrence. Steam for processes may be required at several pressures which greatly influence what may be done with existing equipment, but advances in the field of high steam pressures have made it possible to apply economies in this type of plant which were not practical a decade ago.

Any plant improvement must produce a saving sufficient to return a satisfactory profit over and above fixed charges on the cost of the work. What constitutes a satisfactory profit varies in different cases. It may be stated as a general rule, however, that no expenditure for improvements in an industrial power plant is justified unless it will produce a net return at least equal to what the same amount of capital would produce, if used in the manufacturing end of the business.

In making estimates of both capital and operating

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costs, there is danger of being too optimistic. The tendency to regard the thing desired in a favorable light is so strong that there is always likelihood of underestimating costs of both construction and operation.

Boiler Plant Modernization

Most fruitful as a field for improvements in existing equipment is the boiler plant. The theory of boiler and furnace design of the earlier days was that, the closer the heat absorbing surfaces were to the fire, the better would be the heat absorption from the fuel. The rate of steam production generally accepted as a maximum 10 or more years ago is far below that which is considered good practice today. Many boilers operating today are set so low as to prohibit either efficient combustion or operation at high steaming rates. In such plants improvement in efficiency and an increase in steaming capacity can be secured by increasing the furnace height and combustion volume. Buildings were not usually built, however, any higher than was necessary to house the contained equipment. The tops of boilers are up to the roof trusses and ash pits are at or near the basement floor. Increasing the height of existing boiler furnaces is, therefore, often difficult. To increase the efficiency and steaming capacity of such a plant without radical and expensive changes requires that the engineer's ingenuity and experience be worked to the utmost.

In instances where head room is limited, a reasonably efficient pulverized fuel installation can sometimes be substituted for an unfavorable stoker installation. Such a change will permit operation at high ratings in addition to producing an increase in efficiency. The stoker and ash pit occupy space that can be used for combustion volume in the pulverized fuel furnace. The head room used for ash pits and ash cars is frequently more than is necessary for a satisfactory sluicing system for pulverized fuel ash.

Development of the water-wall furnace has opened up a field for improvement of old boiler plants that in many cases proves of great value. With refractory furnace walls, the fuel burning rate is limited by the point at which spalling and fusing of the brickwork becomes so great as to be prohibitive and this point may be well below the economical fuel burning rate. With water walls, the fuel burning rate is limited only to that at which combustion efficiency becomes too poor. The amount of steam that can be produced in a given boiler is limited only by the amount of fuel that can be burned under it. The amount of fuel that can be burned is limited by the furnace volume and the point at which the power required to draw the furnace gases through the boiler is so great as to offset the advantage of further increase in steaming rate. With modern equipment boilers may be operated at steaming rates in excess of 400 per cent (13.8 lb. from and at 212 deg. F. per sq. ft. heating surface). In addition to the increase in possible steaming rate, the cost of furnace maintenance is much less with water walls than with refractory settings.

Kearny Plant

Substitution of this kind is now being made at Kearny Generating Station of the Public Service Electric and Gas Co., which illustrates what can be accomplished by substituting water walls for refractory settings in an existing plant.

Twelve of the fifteen stoker-fired boilers in this station had refractory furnace walls. The existing boilers with refractory furnaces could not satisfactorily be operated continuously above about 235 per cent of rating and were sufficient, with a suitable allowance for spare capacity, to produce only the steam required for the existing generating equipment. If a 75,000-kw. unit were installed with boiler equipment similar to the old, some 10,000 hp. of new boilers would be required.

It was found that the installation of water walls on the existing boiler furnaces would permit an increase in the average continuous steam production of about 600,000 lb. per hr. This is sufficient to furnish steam to operate an additional 75,000-kw. unit at its most efficient load. The total cost of providing this additional generating capacity will be much less than that of a complete installation of boilers and generating equipment, thus providing additional capacity at relatively low cost, also materially reducing the cost of furnace maintenance for the whole station.

Many manufacturing plants operate two or more boiler plants. In such instances it may be possible by changes of the kind discussed to increase the capacity of one plant enough so that one or more of the others could be shut down. The operating cost, other than fuel, in the plant in which the changes are made would in all probability be reduced, that in the plant shut down would be eliminated and the space occupied by the shut down plant would be available for other uses.

Since about 1921, the use of air preheaters has increased until today their installation in new plants is quite general. It is likely that instances will be found where the installation of air preheaters alone will produce hardly sufficient saving to warrant the expenditure of the necessary capital. Air preheaters increase the draft required and decrease the draft available from existing chimneys because of the reduction of flue gas temperature, hence, mechanical draft apparatus will usually have to be added along with the air preheaters. This may be profitable as part of a general reconstruction and improvement program and should, in such cases, be given consideration.

High Pressure Is Not Hazardous

In 1920, 250 to 275 lb. per sq. in. was generally accepted as a maximum conservative steam pressure. Since then developments in the use of higher steam pressures have been extensive, the Benson Cycle, in use somewhat experimentally in England, operating with a boiler pressure of 3200 lb. per sq. in. It has become evident that, with the improvement which has taken place in design, materials and methods of manufacture of steam equipment, high pressure alone constitutes no hazard in the steam plant.

In a steam power system, the greatest loss is the latent heat of vaporization which is discharged to the condenser. This loss is in the neighborhood of 1000 B.t.u. per pound of steam, regardless of the initial pressure or temperature. If the initial pressure and temperature of the steam are increased, the amount of heat contained in the steam, in addition to this necessary loss and which can be converted into useful work is increased. Obviously, this decreases the percentage of unavoidable loss.

In a steam plant containing generating or other power equipment operating at say 150 to 200 lb. per sq. in. it is possible to install one or more high-pressure

boilers (600, 800 or more lb. and high temperature) which will supply steam to a non-condensing turbine. This turbine will exhaust steam at the proper pressure and temperature into the existing steam header system, thence to the old low-pressure equipment. With such a system, additional electrical energy or mechanical power is produced with no increase in the amount of steam generated. Additional capacity provided in this manner requires no condenser or auxiliaries and involves no increase in the amount of condensing water.

The illustration, based upon conservative figures, shows what may reasonably be expected as approximate additional energy that can be produced by this expedient. The exact amount will depend upon the efficiency of existing equipment.

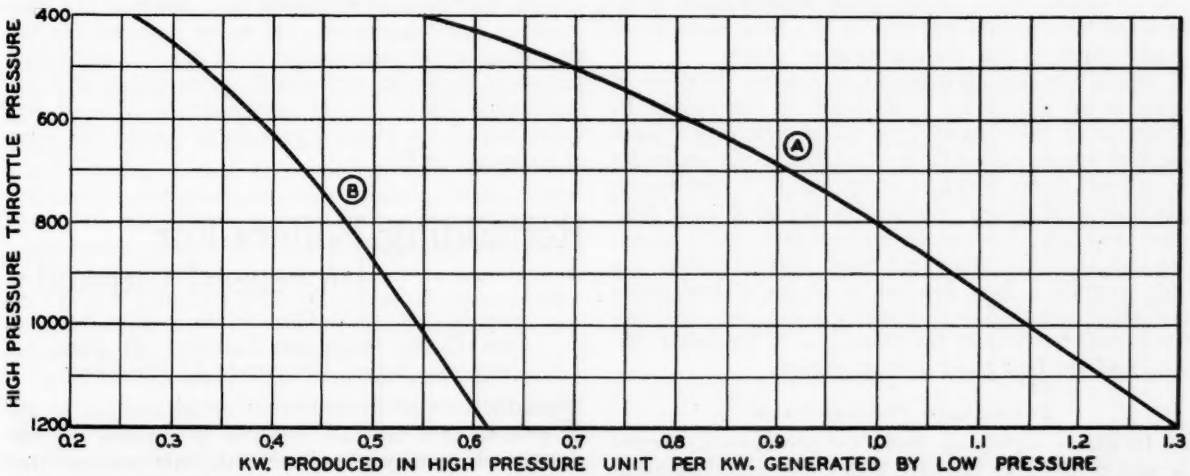


FIG. 1. RELATIVE POWER FROM HIGH-PRESSURE UNIT EXHAUSTING TO LOW-PRESSURE UNIT: A FOR LOW-PRESSURE EXHAUST AT 3 LB. GAGE. B FOR LOW-PRESSURE EXHAUST AT 2-IN. MERCURY ABSOLUTE

Usually a system of this kind can be operated with no increase in plant labor costs and frequently with a reduction in the cost of labor, of repairs and of maintenance.

Actual Plants

Installation now being made in the Burlington Generating Station of the Public Service Electric and Gas Co. of New Jersey shows what can be accomplished with such an arrangement. This station consisted of a number of old boilers operating with a steam pressure of 200 lb. per sq. in. and 150 deg. superheat, electric generating equipment comprising three turbo-generators of 12,500 kv-a. capacity each. Study of the situation developed the fact that a turbine of 18,000 kw. capacity using steam at 650 lb. with a total temperature of 850 deg. and exhausting at 200 lb. per sq. in. would pass enough steam to operate the three existing 12,500 kv-a. units at full load.

The Company's plans contemplated an extension of this station in the near future, using large turbine and boiler units with a throttle steam pressure of about 650 lb. and 850 deg. total temperature. It was, therefore, feasible to install one boiler of the size and for the pressure to be used in this proposed extension and use it to supply steam for an 18,000-kw., back-pressure unit. This installation possessed the following advantages:

(1) Produced an increase in station capacity of 18,000 kw.

(2) Reduced the average full load station heat rate from about 24,000 to about 15,000 B.t.u. per kw-hr., thus making one of the least economical elements in the Company's system into one of the most economical.

(3) Permitted discontinuing the relatively expensive operation of the old boiler plant.

(4) Made economical use of the three turbines, which without this change were nearly obsolete. With this system in operation, the three 12,500 kv-a. units become prime base load capacity whereas previously because of poor economy, they were usable only for peak load operation.

Another instance illustrative of what can be accomplished by superimposing high-pressure boilers and non-condensing turbines on an existing generating system is the installation recently put in operation in Station "B" of the San Antonio Public Service Co. This station contained generating equipment operating at 175 lb. per sq. in. On account of this steam pressure, low as compared to present-day practice, the station was inefficient and for that reason nearly obsolete. A boiler to generate steam at 1350 lb. and 810 deg. F. total temperature was installed with a 7500-kw., non-condensing turbine generator, this combination supplying sufficient steam to produce a maximum of 20,000 kw. in the old generating equipment.

Here also, 7500 kw. additional capacity was provided near the load center. The cost of the installation was low compared to that of providing a complete generating unit consisting of boilers, turbine-generator, condenser and auxiliaries and the additional capacity was provided without additional condensing water, which was a special advantage in this case. Overall heat rate of the station was improved so as to make it compare favorably with the other generating equipment on the system.

Reheat, Regenerative Heating and Heat Balance

High initial steam pressure in this installation makes reheating necessary. The saturated steam from the boiler is at a temperature high enough so that it can be used for reheating the exhaust from the high-pressure turbine, the reheater being located above the boiler and the steam condensed in it returning to the boiler drum by gravity.

Several related factors connected with the use of a high-pressure boiler and turbine superimposed upon an existing low pressure system increase the economy of the system as a whole. The use of regenerative feed-water heating systems has increased to a considerable degree the normal temperature to which boiler feed water is customarily heated, the advantages of this high temperature feed from the standpoint of both economy and boiler conditions being more fully realized. With the high-pressure system, it is practical and economical to install a heater using steam from the exhaust of the high-pressure turbine. Frequently, it is also possible to bleed steam from existing turbines and secure a regenerative system which, though perhaps not ideal in pressure and temperature distribution will be a worth while improvement on the non-regenerative system.

Often it is also advantageous to convert the drive of some or all auxiliaries from steam to electricity. In plants using the exhaust from steam-driven auxiliaries for feed-water heating there is usually either an excess of exhaust steam which must be wasted to the atmosphere or a deficiency resulting in low feed-water temperature. Use of motor-driven auxiliaries with an extraction or regenerative feed-water heating system not only permits a heat balance to be maintained automatically under all load conditions but also increases the overall economy of the plant, due to the better efficiency of the feed-water heating system.

Power from Process Steam

In plants supplying steam for processes at several pressures, the high-pressure boiler and non-condensing turbine will frequently produce surprising economies. Many industrial processes require steam at pressures as high as 150 lb. which, in the older plants is supplied directly from the boiler plant. If a high-pressure boiler is installed and steam for process work is generated in it to be passed through a turbine exhausting at the desired pressure, little additional coal need be used and a considerable quantity of electrical energy can be produced at very high thermal efficiency. The heat rate for energy produced in this manner is of the order of 5,000 B.t.u. per kw-hr.

Mercury Vapor

The mercury vapor-steam cycle has been developed to a commercially successful point. In this system, mercury evaporated in a fuel-fired boiler is expanded in a turbine which drives an electric generator and passes thence to a condenser. This system may be installed in an existing power plant and the steam produced by it used to replace that from uneconomical boilers.

So far the only commercial installation made is in Hartford, Connecticut, at the South Meadow Station. Tests indicate that the system will produce about 12.5 lb. of steam per kilowatt-hour generated by the mercury vapor turbine. This installation operates with a steam pressure of 270 lb. gage and a total steam temperature of about 700 deg. F. The steam production varies somewhat with different pressures and temperatures.

At the Kearny Generating Station of the Public Service Electric and Gas Co. a system of this kind is now being installed which will have a capacity in the mercury vapor turbine of 20,000 kw. and will produce at full load about 325,000 lb. of steam per hour at 365 lb. gage pressure and 750 deg. F. total temperature.

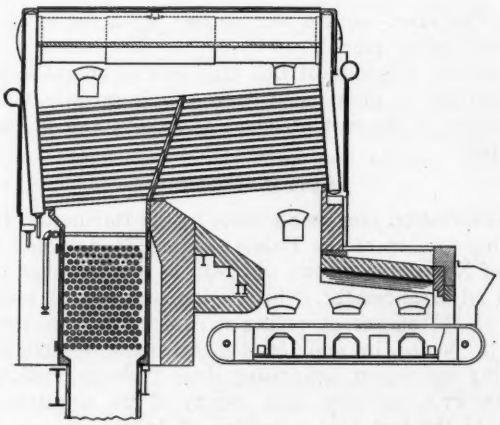
Overall heat rate of the combined mercury vapor and steam cycle will be about 10,000 B.t.u. per kw-hr. By installing this equipment, the capacity of the station is increased 20,000 kw. and the average heat rate for energy produced by this cycle will be much better than would be attained by a like increase in capacity at the existing steam pressure and temperature.

Frequently, it is found necessary to increase the capacity of an old plant in which the existing equipment has an expected operating life of perhaps 5 yr. In other words, most of the plant equipment will be worn out and require replacement in something like 5 yr. In such a case, consideration should be given to the installation of equipment of a modern type, designed for high pressure and temperature but to be operated for the time being at the same conditions as the old plant. This procedure leaves the way clear to secure a high efficiency installation when the old equipment is replaced but makes use of the existing equipment for the full term of its operating life.

Rebuilding Boilers For Increased Capacity

New Baffling and Economizer at Burling Slip Plant Increased Capacity 45 Per Cent and Raised Efficiency 10 Per Cent

PROPER CONSIDERATION of all avenues of approach often makes it possible to improve the efficiency and capacity of a plant with little expense. One of the interesting remodeling jobs was that of the twelve



ARRANGEMENTS OF THE TWELVE BOILERS AFTER THE ECONOMIZERS WERE ADDED AND THE BAFFLING CHANGED FROM THREE TO TWO PASS

10,430 sq. ft. Edge Moor boilers in the Burling Slip plant of the New York Steam Corp. These boilers, installed in 1913, were on two floors and were fired by chain grates.

By changing the baffling from three to two pass and installing Foster Wheeler extended surface 7254 sq. ft. economizers, the capacity of the plant was increased from 900,000 to 1,300,000 lb. of steam per hour. Furthermore, the efficiency at 75,000 lb. per hour was increased from 68 to 80.5 per cent. The cost of remodeling was low because the changes were made without increasing the size of the building.

REHEAT — Practice, Operation *and* Control

Regulation of Superheat. Desuperheaters for High Pressure and Reheated Steam. Bypass from High Pressure to Low Pressure System. Putting the Boiler in Service.

AFTER THE STEAM SECTION of a series reheater is completely cut out the reheat temperature varies with the rate of firing. Characteristics are such, however, that the final reheat temperature curve flattens out after this point so that the maximum steam temperature will not greatly exceed the desired average temperature. If it were absolutely necessary to maintain a constant temperature of the reheated steam at all ratings, it would be possible to install sufficient surface to take care of low loads and make use either of desuperheater or to have part of the steam bypassed around the gas reheater at higher loads as explained earlier.[1]

It is not impossible that future design may involve the use of larger gas reheaters so that the required reheat steam temperature will be obtained at low ratings without the necessity of steam reheaters. This depends upon the type of boiler used and the load conditions. It may be that the series type would not be justified on a base load station although advantageous under variable load conditions. Where the gas reheater section follows the superheat section (in the gas path) as at South Amboy, the use of a steam reheater section in connection with the gas section gives a more reasonable first cost. It does not require the excessive surfaces which would otherwise be necessary with the comparatively cool gases at low loads. It also avoids the use of an additional desuperheater, baffles or bypass as mentioned before.[1]

Desuperheating

Outside of the cost of additional gas reheater surface desuperheater and bypass control equipment, elimination of the steam section would probably offer no more difficulty than regulation of superheat today. Superheat regulation has been obtained by using combination superheaters and by desuperheaters. Combination superheaters will be discussed later.

Desuperheaters are used at South Amboy, the arrangement being shown diagrammatically by Fig. 1. The desuperheater is installed on the side of the boiler just below the drum. In the steam main to the high pressure turbine is a thermometer bulb which actuates the primary regulating device or contactor. When the temperature deviates from the desired normal the contactor operates through the control drive to correct the condition. The control drive is connected, through a reduction drive, to a butterfly by-pass valve, allowing more or less steam to pass through the desuperheater depending upon whether the temperature is above or below normal. Heat liberated by the steam in passing through the tubes of the desuperheater is absorbed by the water surrounding the tubes.

This desuperheater is connected to the boiler drum with three lines as shown, two circulating lines and one steam vent line. The two circulating lines prevent undue concentration of the boiler water in the desuperheater shell because constant circulation is maintained by the heating effect of the superheated steam line where it comes in close contact with the return circulator. Steam made in the desuperheater passes directly to the boiler drum through the vent line. This is not, of course, the only desuperheater arrangement possible. What might be termed stage superheating is practiced in Europe. Two such arrangements are shown in Fig. 2. The first is a spray type desuperheater, the second does not differ fundamentally from the South Amboy desuperheater shown by Fig. 1 except that the superheating element is split with the desuperheater between them. This is done to protect the superheater element itself. If the desuperheater follows the superheater it is evident that the last sections are subjected to high temperature, whereas, if the elements are divided, temperatures in all parts of the superheater elements are held within the set maximum. With the cooler system, the first section of the superheater is never subjected to excessive temperatures. This need of superheater regulation is common to all stations regardless of reheat.

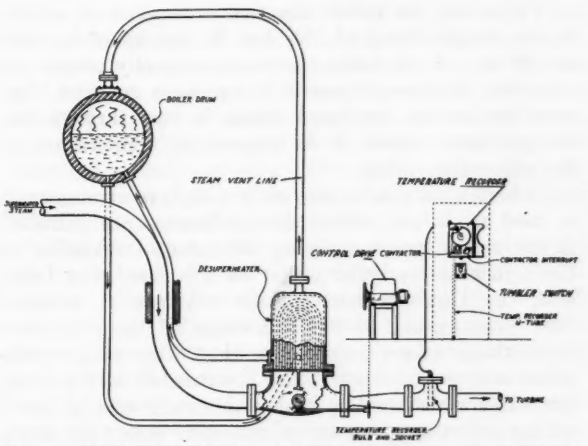


FIG. 1. DESUPERHEATER AS INSTALLED ON HIGH PRESSURE LINE AT SOUTH AMBOY

Another desuperheater arrangement which is used in

[1]See Power Plant Engineering, page 589, August 1, 1932.

reheat stations is shown by Fig. 3. This is the temperature regulation system used at Lakeside to protect the reheater against excessive temperatures if the high pressure turbine should suddenly trip off the line. In the usual boiler this condition could be taken care of by the safety valves until the fuel feed could be reduced.

With a reheat boiler, however, this would leave the reheater with no steam flow through it, subjected to radiation from the hot furnace. To avoid this condition a quick acting bypass valve is installed between the high

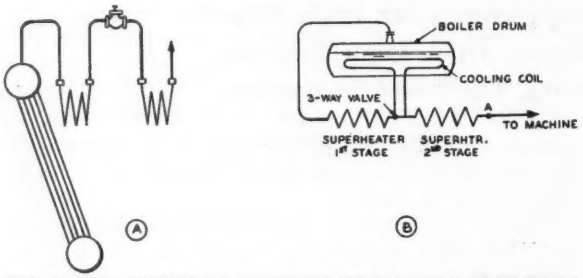


FIG. 2. TWO TYPES OF SUPERHEATERS USED IN EUROPE

pressure outlet from the superheater and the low pressure line to the reheater. This bypass opens automatically when the throttle valve trips, the 1200 lb. steam being reduced to 350 lb. by means of a fixed expansion nozzle.

Following the nozzle the temperature is of course in the neighborhood of 725 deg. F. instead of the 450 or 500 deg. F. at which the steam normally enters the reheater. This would result in excessive reheater temperatures so the bypassed steam is run through the desuperheater where it is reduced in temperature to the saturation point.

A somewhat similar but more extensive arrangement is used at Edgar, where desuperheaters are installed in the steam lines supplying the integral reheaters in the high pressure boiler units. In this case, as at Lakeside, the high pressure turbine exhausts at constant back pressure and as the load drops off the high pressure exhaust steam temperature rises. Beyond a certain point this rise in temperature is corrected with a desuperheater which can be under automatic control based on the outlet temperature of reheater. After the steam is desuperheated to the proper temperature it is led to the reheat section of the boiler and delivered to the low pressure turbine.

High pressure boilers are tied together by common mains after the high pressure superheaters, before and after the reheaters, hence the boiler load does not fluctuate directly with the loads of the high pressure turbines and desuperheaters are required to maintain safe conditions. The movable reheater damper in the high pressure boiler units,[2] so equipped, is essential to the operation of the plant. It allows flexibility in the flow of steam through the various reheaters and protects them from excessive temperatures without the use of the desuperheaters, the use of which is kept at a minimum. If the load on the high pressure turbine is suddenly lost, the entire high pressure turbine is bypassed and steam is led directly to the desuperheater and then to the reheat section of the boiler and from there to the low pressure turbine.

[2]See Power Plant Engineering, page 840, Aug. 15, 1931.

At Northeast Station where a high pressure unit was also superimposed on a low pressure station a somewhat different arrangement is used. The valve used at this plant is of the quick opening type installed in a direct connection between the high pressure superheated steam manifold and the desuperheater whose outlet is in turn connected with the reheater inlet on the 300 lb. system.

The quick opening feature of this valve permits practically instantaneous opening from the boiler control board by means of a push button. It was originally intended that this control feature should be hooked up to the turbine throttle valve so that in case of the turbine tripping, the bypass would automatically open. Realizing, however, that it was possible to lose complete load on the generator without the throttle tripping, this feature became of considerable less value and was never hooked up.

While this quick opening valve is designed as stated above, it can be opened by hand to any desired amount, thus permitting any distribution of steam to the high pressure turbine, desuperheater and low pressure system. Recourse is made to this feature when the boiler units are being started so as to permit of saturated steam into the radiant reheaters for protection before the high pressure turbine is in service. It is likewise used to permit use of the entire capacity of both high pressure boilers in the event the high pressure turbine is operating under reduced load thus, in this case, part of the steam would be going to the high pressure turbine and part of it direct to the reheaters through the desuperheater. It also permits complete use of the boilers with the high pressure turbine shut down.

Starting Boilers

This matter of protecting the reheater and superheater coils is doubly important in the case of radiant

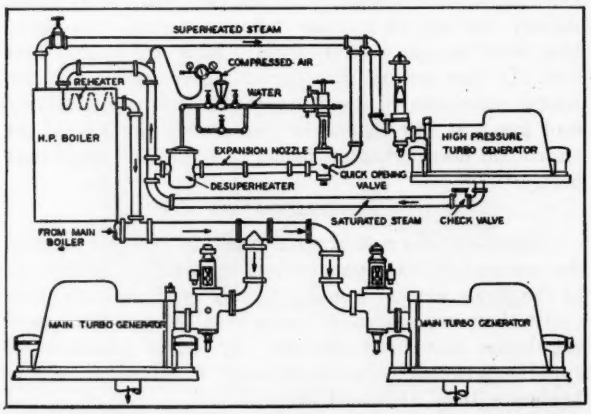


FIG. 3. BYPASS DESUPERHEATER AS INSTALLED AT LAKESIDE TO HANDLE FLOW OF HIGH PRESSURE STEAM WHEN TURBINE TRIPS OFF THE LINE

elements. New design of radiant elements consists of light small tubes with practically no heat storage in the metal. The starting problem is an important one because during the starting period there is no steam available to cool them without overheating. There is no storage of heat in the metal to be depended upon to prevent overheating. Cooling with steam from other boilers or with the boiler's own steam after exceeding atmospheric pressure was, at Lakeside, found to be not only inadequate but impractical, calculations showing

that reasonable-sized bleeders would only give a false sense of security.

Furnace temperatures taken during experimental work suggested that if the coal-feed rate was set at a certain value immediately upon lighting the boilers and maintained uniform until the header pressure was reached and steam flow created, starting would be reasonably rapid and maximum flame temperature in the superheaters would not exceed 1000 deg. F. Obviously, the tubes could not exceed the flame temperature regardless of the time they were exposed.

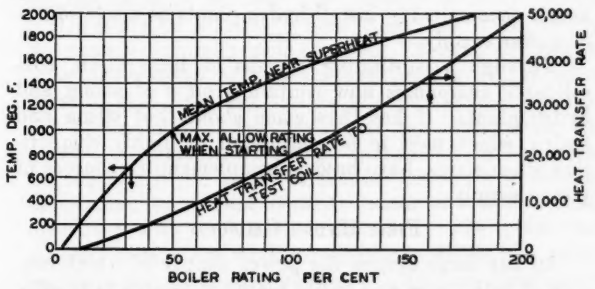


FIG. 4. TEST DATA SHOWING THAT IF 50 PER CENT COAL FEED IS NOT EXCEEDED DURING STARTING, FURNACE TEMPERATURE WILL NOT EXCEED 1000 DEG. F.

Previous starting practice with the heavy forged and cast elements consisted of gradually increasing the coal-feed until it became quite high upon opening of the non-return valve. This consumed three hours when starting with cold boiler water. Special steady coal feed method of starting requires 4 hr. but is considered practical in view of the benefits and the fact that studies of the practices of water flooding and the circulation of steam through superheaters when starting boiler units indicate that an exacting test of metals occurs at that time. Figure 4, from the N.E.L.A. proceedings, shows test data obtained early at Lakeside for the purpose of learning how a radiant superheater of ordinary 2 in. tubing in series with a convection superheater could be brought into service without overheating. This test data shows that if the coal feed was maintained at the value corresponding to 50 per cent boiler rating (as measured by total feeder revolutions) until the non-return valve opened, the maximum metal temperature reached was 900 deg. F. higher. The ordinary operating temperature of the elements was between 900 and 950 deg. F.

Speaking before the A.S.M.E., M. K. Drury said: "Element-metal temperatures, furnace temperatures, radiant-heat transfer rates and all significant information were taken continuously during the starting and first days of operation. Conscientious, practical opinion conceded only a few hours life to the new elements and reliance upon theory, only, was not reassuring enough to eliminate doubts as to their safety after passing the starting period. One had only to look at the small tubes projecting into the almost white-hot flames to doubt all theory and suspect rapid failure.

"Contrary to almost general expectations, the simple carbon-steel tubes lasted the day, the week, the month and finally the year, without a single failure. Half of them are still in service after three and one-half years' operation. There are 800 other similar elements of a slightly better metal that have been in service three years with only two failures."

Sensitiveness of the Human Body to Vibrations

By Dr. Walther Parey*

EVERY POWER plant engineer knows the troubles caused by vibrations in the neighborhood of his plant, which are felt even at some distance from their source, possibly causing difficulty with buildings or at least disturbing people. While the effect of vibration on materials is clarified by research because it is somewhat easier to define these effects on strictly inert matter, knowledge of the vibration effects on human beings was missing for a long time. Several authors have reported data on these effects in connection with general vibration research but not in good agreement.

For this reason and because of the importance of correct data on this question, the Institute for Acoustical and Heat Research of the Technical University of Stuttgart (Germany) has carried out a series of tests on the sensibility of the human body to vibrations[1].

The testing apparatus was a heavy platform 6 by 4 1/5 ft. hanging on vertical or horizontal automobile springs so that it could vibrate in any direction.

At the center of gravity of this platform stood a small electric motor with a flywheel, an eccentric load on which caused vibrations whose frequency could be changed between 3 and 70 cycles per second. The amplitudes were changeable between 0.00004 and 0.4 in. These are practical values of frequencies and amplitudes.

Tests were made on the platform with ten persons of different ages and different sensitiveness. Since scientists assume that the vestibule mechanism in the human ear is the organ which feels vibrations, they expected to find,—in spite of the differences of the persons,—regions of sensibility to vibrations similar to those which are known of the sensibility to noise.

Test results verified these assumptions, diagrams showing clearly six different regions of sensibility: No feeling; slightly sensible; sensible; strongly sensible (troublesome); disagreeable (probably injurious after a longer time); very disagreeable (absolutely injurious even after a short time). The boundary between no feeling and slightly sensible is called the threshold of irritation; that between troublesome and injurious is called the threshold of danger. Where these thresholds lie depends on the direction of vibration and on the posture of the body. A standing man is more sensitive to vertical than to horizontal vibrations, while a man lying on his back suffers more from vibrations across the axis of the body than from those parallel to it.

Amplitudes of vibrations which a man feels or even of those which are dangerous to him are very small. A standing man feels a vertical vibration of 10 cycles per second at an amplitude of even 0.0004 in. This frequency begins to be dangerous at an amplitude of 0.008 in. At higher frequencies, e.g. 50 cycles per second, he feels amplitudes of about 0.0001 in. while amplitudes of 0.005 in. become dangerous.

Results of these tests give the means of determining the region of sensibility to which a practical vibration belongs and of concluding whether a vibration is tolerable or disagreeable or even dangerous.

*Berlin, Germany, correspondent.

1H. Reiher and F. J. Meister, Forschung (VDI-Berlin) Vol. 2, No. 11, page 381.

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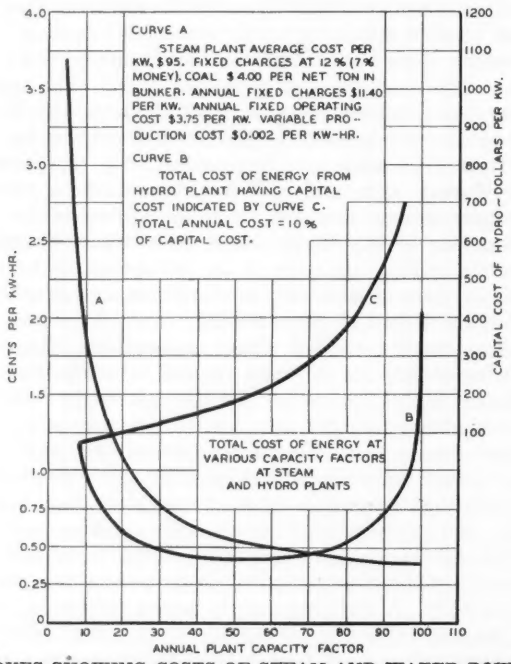
POWER PLANT ENGINEERING October 1932

Economic Balance of Steam and Hydro Capacity

STEAM AND HYDROELECTRIC DEVELOPMENTS CANNOT BE DIRECTLY BALANCED AGAINST ONE ANOTHER BUT MUST BE CONSIDERED IN RELATION TO THE SYSTEM AS A WHOLE.* BY K. M. IRWIN[1] AND JOEL D. JUSTIN[2]

DOWNWARD trends of steam-plant operating costs have often been cited as a reason for favoring steam as a source of power. During the past 20 years has been a remarkable increase in steam-plant efficiencies which seems impossible or unlikely to be duplicated, although it may still be unsafe to predict what the future may offer. In 1931 at least one plant with a single stage of reheat averaged 12,000 B.t.u. for the year and was operating between 200 and 300 B.t.u. less than 12,000 for 6 mo. While predictions of future steam efficiency seem extremely unreliable it is safe to say that the best which can be foreseen is approximately 10,000 B.t.u. when utilizing steam at 2500 lb. and 1000 deg. F., or 8500 B.tu. with the mercury cycle.

In considering steam-generated power costs, considerable speculation is necessary regarding fuel costs. At



CURVES SHOWING COSTS OF STEAM AND WATER POWER PLANTS.

the present time coal is probably being sold at prices that do not provide an adequate return on the coal-mining investment and may even yield little more than the mining cost. While it would seem reasonable to assume that this condition will not persist, the competition of other fuels will tend to hold coal prices down.

In the past many hydro plants were constructed as the sole source of power supply for a community or section. Under such conditions, it is necessary that the minimum flow of the river should be sufficient at time of maximum power demand to give all the power which is required to meet the load. Except in the case of certain favored sections where development costs are low and natural or artificial storage is readily available, or in sections where fuel is extremely high in cost, it is no longer economical to install hydro plants as a sole source of power supply.

Through a continuing process of integration, consolidated companies now contain groups of steam and hydro plants. It has thus come about that steam and hydro, which used to be considered as highly competitive alternatives, have become complementary sources of power supply.

FIRM HYDRO CAPACITY

In any large system the power supply of which consists of both steam and hydro plants, it is always feasible and generally quite economical to supply the requirements of the increasing load through the construction of additional steam capacity. If, however, the system includes available hydro sites, it is necessary to conduct an extensive economic study in order to determine whether the additional load can be most economically supplied by a new steam plant or by a new hydro plant.

As steam is the yardstick by which the economic advisability of hydro must be measured, about the first thing which must be determined with regard to any hydro project (after its physical features have been investigated) is whether the proposed hydro capacity can do the same work which an alternative steam plant might perform on the existing load curve. If the hydro plant can do this, its capacity is said to be "firm." The firm capacity of a hydro plant may be defined as that portion of its total capacity which can perform the same in that portion of the load curve assigned to it as alternative steam capacity could perform.

The minimum 24-hr. power available at the site is sometimes incorrectly spoken of as the firm capacity. This can be true only in the case where there is absolutely no pondage. With large pondage and favorable load conditions, the firm capacity of a hydro plant may be many times the minimum 24-hr. power available. In the case of some existing plants which are parts of large systems and are possessed of ample pondage, the firm power is ten or more times the minimum 24-hr. power available.

INCREMENT COST OF HYDRO PLANTS

Capital costs of hydro plants per kilowatt vary over much wider limits than is the case with steam plants. This is because a much smaller part of the total cost is in equipment and buildings. For any given site and head, the investment in land, riparian rights and dams is very nearly a constant, regardless of the amount of installation. However, the incremental cost of installation, meaning those costs which roughly are proportional to installation, consisting mainly of building, intake conduit and equipment, vary within much narrower limits. An examination of cost data for a number of plants varying in capacity from 3000 to over 200,000-kw., indi-

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[2]Hydro-electric engineer, the United Gas Improvement Co.
*From a paper presented before the A.S.M.E.

cates that the incremental cost of hydro plants in general varies from $55 to $70 per kilowatt of capacity.

The effect of the unusually low increment capital cost of hydro installation in determining the advisable use to be made of a hydro project may be fully understood by a study of the curves. Curve "A" in this figure gives the total cost of energy per kilowatt hour for a modern highly efficient steam plant.

Curve "C" gives the total capital cost per kilowatt of installation for a hydro plant if installed for various annual capacity factors. The plant is a fairly typical hydro plant on a fairly typical American river, having an average annual runoff of about 1.5 c.f.s. per square mile and a range of flow varying from a weekly minimum of 0.15 c.f.s. per square mile up to over 28 c.f.s. per square mile. Thus the larger the installation, the greater the amount of energy turned out by the plant during any given year. It should, however, be remembered that the annual capacity factor of a hydro plant decreases with increased installation. The plant has ample pondage for weekly regulation, which is a prime requisite for any hydro project if all its capacity above that required for minimum stream flow is ever to become firm on the load curve.

Curve "C" then shows for a fairly typical case the tremendous variation in unit capital cost of hydro according to the amount of installation installed. Thus, if the project is planned on a 90 per cent annual capacity-factor basis, the capital cost would be about $580 per kilowatt, whereas if planned on a 20 per cent annual-capacity basis, the capital cost would (by curve "C") be about $100 per kilowatt. It should here be noted that in order to be firm capacity on such a low capacity-factor basis, it would probably be necessary for the connected load to be three or four times the installed hydro capacity, and thus the load would absorb all hydro energy generated. The curves are applicable only for the case where all hydro capacity installed would be firm capacity on the load curve. In fact, it seldom pays to consider hydro installations on a low-capacity factor basis unless all the capacity is firm.

In order to obtain curve "B" it was necessary to obtain the amount of energy available for the installation required to give the various capacity factors. For this purpose, flow and power duration curves of the fairly typical stream selected were utilized. Total annual charges on hydro were taken at 10 per cent of capital cost and to get the total cost of energy, the annual cost per kilowatt was divided by the energy produced per kilowatt of capacity. Curve "B" shows the typically very high cost of hydro energy as compared to steam at high capacity factors and its relatively low cost compared to steam on low capacity factors. At a 70 per cent capacity factor, it will be noted that in the given case the costs of steam and hydro power are equal.

While there are many situations in which, if curves similar to those shown were plotted, the results obtained would be quite different from those shown, nevertheless, it is believed that the curves are fairly typical for many situations.

Most emphatically the curves should not be interpreted as showing that either steam or hydro is the cheaper source of power supply. The only thing that ever makes it feasible to install a hydro project on a relatively low annual capacity-factor basis is the existence of a connected load several times the hydro capacity, served largely by steam plants.

Under more or less exceptional conditions, hydro plants having very high annual capacity factors are economically feasible. Niagara Falls is a frequently cited example of this. There are also many projects on rivers which are well regulated by natural or artificial storage where costs on high capacity factors are relatively low.

In the past many hydro plants were constructed as the sole source of power supply for a company.

Mercury Walls Increase Capacity

MERCURY TURBINES as a source of power generation have been seriously considered for a number of years, the most noticeable work of this kind being carried on by the Hartford Electric Light Co., Hartford, Conn., at the South Meadow plant.

Thermal efficiency of the mercury binary cycle is good, being in the order of 35 per cent when utilizing the steam output of the condenser-boiler in a 35,000 kw. steam turbine with steam conditions 250 lb. gage, 700 deg. F. Tests at Hartford showed that 1-kw. hr. could be delivered at the switchboard for 9930 B.t.u. in the fuel and that actual operating records for one year showed a fuel rate of 10,250 B.t.u. per kw. hr.

Two 20,000 kw. plants are now being built, one for the new power house of the Schenectady, N. Y., works of the General Electric Co. and another for the Kearny Station of the Public Service Electric & Gas Co. of New Jersey. These units will be installed in approximately the same space as the 10,000-kw. Hartford unit, the increased rating being made possible by mercury walls installed in the upper half of the furnace and water walls in the lower half. The mercury pressure has also been increased from 70 to 125 lb. gage.

	Hartford	Kearny	Schenectady
Load on mercury turbine, kw.	10,000	20,000	20,000
Speed of mercury turbine, r.p.m.	720	900	900
Total steam from unit, lb.per hr.	129,000	325,000	325,000
Steam pressure, lb. gage	275	365	400
Steam temperature, deg. F.	680	750	760
Mercury vapor pressure at turbine, lb. gage	70.7	125	125
Mercury vapor temperature at turbine, deg. F.	884.5	958	958
Vacuum of mercury condenser, in.abs.	1.5	3.0	3.0
Temperature of mercury vacuum, deg.F.	440	485	485

Although both units will burn pulverized coal, there is considerable difference in the arrangement. In the Schenectady plant the mercury turbine and condenser boilers are located on the same level as the mercury boiler and the mercury condensate will be pumped into the boiler instead of being fed by gravity. The steam produced will be used in the factory for process work and heating. The electrical output will be supplied to the lines of the New York Power & Light Co.

At Kearney the 325,000 lb. per hour of steam produced in the condenser-boiler will generate 33,000 kw. in a steam turbine, giving a total output to the mercury equipment of approximately 53,000 kw. Operating conditions of the three plants are shown in the accompanying table.

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Calculating Pipe Sizes and Pressure Drops

NOMOGRAPHIC CHART ASSISTS IN DETERMINING VELOCITIES AND PRESSURE DROPS FOR SATURATED AND SUPERHEATED STEAM WITHOUT REFERENCE TO TABLE. BY G. A. GAFFERT, MECHANICAL ENGINEERING DEPT., SARGENT & LUNDY, INC., CHICAGO, ILL.

PROBLEMS ARISE continually in the design of steam-electric stations requiring selection of pipe sizes for certain conditions. Many hours are spent computing internal pipe areas, friction coefficients and other variables to arrive at definite pipe sizes. The writer, having made numerous computations of this nature, conceived the idea of a nomographic chart for solution of such problems.

This chart shows the following features: The usual known quantities are the quantity of steam to be handled and the state conditions of pressure and temperature. To obviate the use of a steam table, a graphic table has been incorporated in the chart. All values of temperature, pressure, and specific volume have been taken from the latest and commonly accepted steam tables by J. H. Keenan. It is possible to determine state conditions and by passing horizontally to the left determine specific volume from the chart. For saturated and superheated steam, the specific volume can be determined readily by direct reading or interpolation. For wet steam, the following procedure is suggested: Determine specific volume corresponding to saturated steam from chart and then multiply by the quality. Relocate the point on specific volume line.

Left-hand portion of the chart is for the purpose of determining velocity of flow. The formula graphically shown on the chart is:

$$W \times S = 60\,A \times V$$

Where:

W = steam flow in lb. per hr.
S = specific volume in cu. ft. per lb.
A = actual internal area of pipe in sq. ft.
V = velocity of flow in ft. per min.

Whereas area in square feet is required in the above formula, it is more convenient to work with nominal pipe diameters. For each pipe size and pressure standard, the nominal diameter has been substituted for its internal area. The pressure standards on the left of the area axis are those conforming to the latest Tentative American Standards Committee for lap-weld pipe and seamless tubing. These standards are usually adhered to in steam station design, the particular pressure standard depending upon the throttle temperature and pressure conditions for the plant in question. For the convenience of those using standard weight, extra heavy, and double extra heavy pipe, the nominal diameters corresponding to internal areas of these pipes have been located on the right side of the area axis.

Drawing two straight lines determines the velocity of flow. A step is then made from the velocity axis to the right-hand side of the chart, using this axis already located as part of the graphic representation of the formula:

$$P = \left(\frac{V}{60}\right)^2 \frac{K}{S}$$

in which

$$K = \frac{0.0014}{D}\left(1 + \frac{3.6}{D}\right)$$

Where P = pressure drop in lb. per sq. in. per 100 ft.
V = velocity in ft. per min.
S = specific volume in cu. ft. per lb.
K = a constant for a given pipe size.
D = actual internal pipe diameter in in.

A few exemplary remarks may be made regarding the scales chosen. Modern practice involves steam flow at pressures from about 5 lb. absolute up to 1500 lb. and approximately 900 deg. F. Specific volume for conditions between these limits can be read from chart. It is believed that an upper limit of 600,000 lb. per hr. is sufficient for steam flow in any single line. The velocity scale was purposely chosen with limits shown to include the range usually considered as good practice and to allow reading velocity readily to the nearest 100 ft. per min., which is usually of sufficient accuracy to the designer. The pressure drop scale was not carried above 40 lb. per sq. in. per 100 ft., as this is well in excess of conservative and economical design.

To illustrate the use of the chart, assume the following conditions:

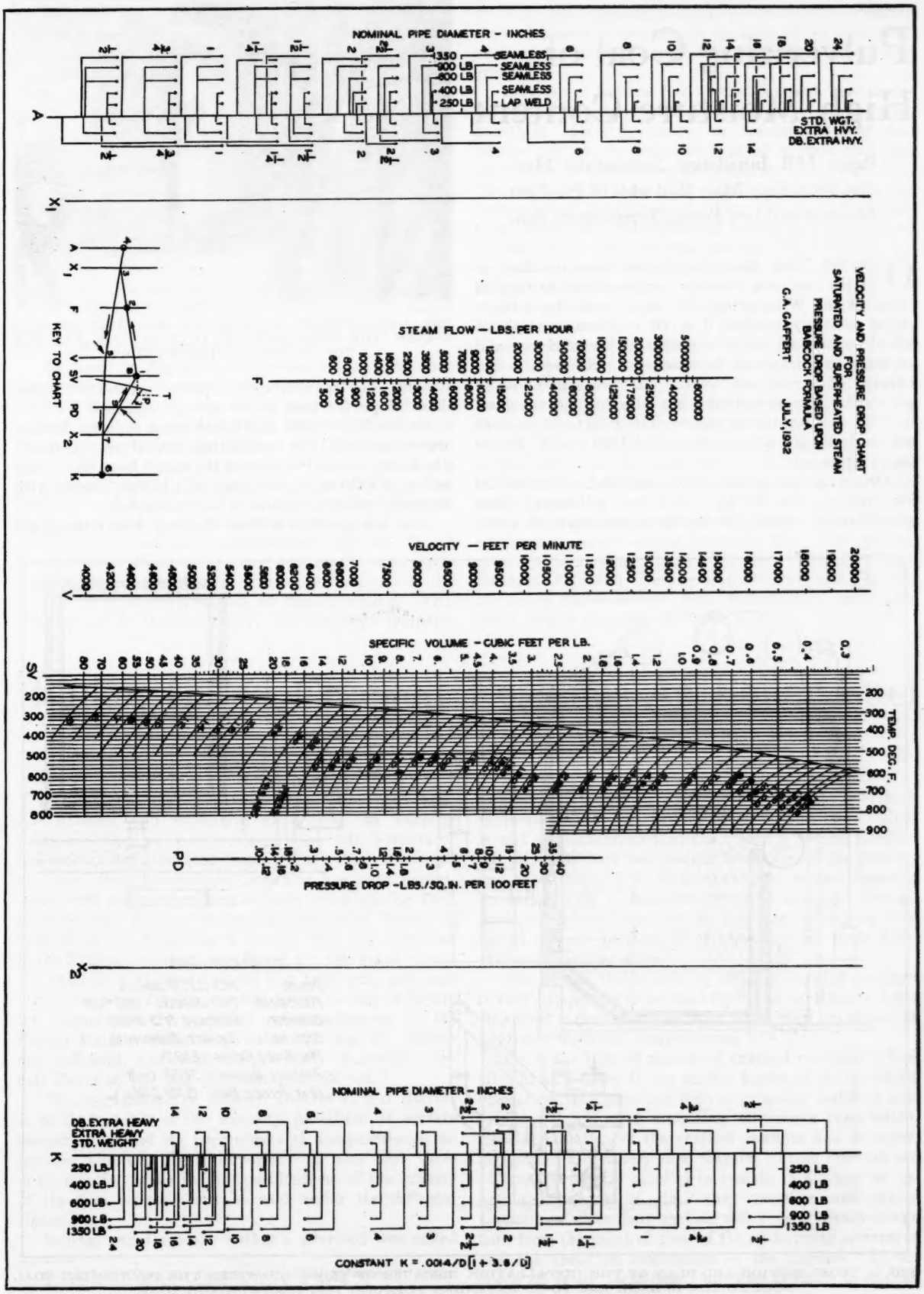
Steam flow, 150,000 lb. per hr.
Pressure, 600 lb. absolute.
Total temperature, 800 deg. F.
Piping pressure standard, 900 pounds W.S.P.
Required: Pipe size corresponding to good practice for a boiler lead and corresponding pressure drop per 100 ft.

SOLUTION

Locate state point and draw a horizontal line intersecting specific volume axis, locating specific volume point 1.18. Lay a straight edge against this point and 150,000 lb. per hr. on flow scale. Draw a line cutting the unmarked axis X_1 adjacent to the area axis. Mark this point and, placing scale against this point, try the several points (900 lb. W.S.P.) on the area axis and note velocity resulting. Suppose an 8 in., 900 lb. W.S.P. line is selected, velocity will be 10,000 ft. per min.

To check pressure drop, join this point on velocity scale with point 8 in.—900 lb. W.S.P. on K scale, cutting unmarked axis X_2 adjacent to K scale. Draw a line between this last point of intersection and specific volume point on specific volume scale. This line will cut the pressure drop scale at 6.8 lb. per sq. in. per 100 ft., which should be satisfactory if the line is not too long.

The author has found it advantageous to make a permanent record of each pipe line of importance. One sheet may be used for each line, each sheet being a print of an original tracing. The various trials are made in light pencil and final selection marked in ink, with complete steam conditions, size of line chosen, pressure standard, velocity and pressure drop noted on blank space on chart.


NOMINAL PIPE DIAMETER - INCHES
1350 LB SEAMLESS
900 LB SEAMLESS
600 LB SEAMLESS
400 LB SEAMLESS
250 LB LAP WELD
STD. WGT.
EXTRA HVY.
DB. EXTRA HVY.
KEY TO CHART
STEAM FLOW — LBS. PER HOUR
VELOCITY AND PRESSURE DROP CHART FOR SATURATED AND SUPERHEATED STEAM
PRESSURE DROP BASED UPON BABCOCK FORMULA
G.A. GAFFERT JULY, 1932
VELOCITY — FEET PER MINUTE
SPECIFIC VOLUME - CUBIC FEET PER LB.
TEMP. DEG. F.
PRESSURE DROP - LBS./SQ. IN. PER 100 FEET
NOMINAL PIPE DIAMETER - INCHES
DB. EXTRA HEAVY
EXTRA HEAVY
STD. WEIGHT
250 LB
400 LB
600 LB
900 LB
1350 LB
CONSTANT K = .0014/D[1 + 3.6/D]

Pulverizing Coal of High Moisture Content

Paper Mill Installation Successfully Handles Local Strip Mine Coal with 14 Per Cent Moisture and Low Fusing Temperature Ash.

ONE OF THE interesting boiler room installations of the year was recently completed by the Orenda Corp. at the Wilmington, Ill., paper mill. It is interesting not only because it is an excellent example of rebuilding an old boiler to obtain higher efficiency and capacity but because of the successful pulverization and burning of a local coal with a moisture content of 14 per cent. This installation has also burned the local 3/16 in. duff containing approximately 20 to 22 per cent ash, 18 to 20 per cent moisture and 1880 deg. F. fusion temperature ash.

Originally the power plant consisted of three 750 kw. turbines, four 300 hp. stoker fired boilers and three geared water wheels developing a maximum of about 700 hp. The balance of the power necessary is purchased from the local public utility company.

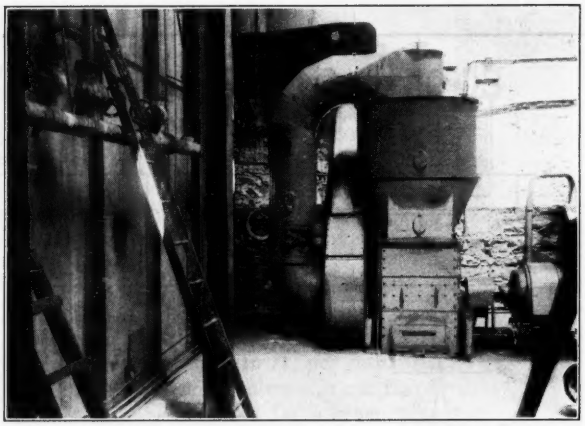


FIG. 1. PULVERIZER LOCATED AT ONE SIDE OF THE BOILER. THE PREHEATED AIR DUCT IS VISIBLE IN THE TOP CENTER OF THE PICTURE

In the fall of 1931 additional steam capacity became imperative and after considering several possibilities it was finally decided to remove the stoker from one of the boilers, a 8230 sq. ft. Stirling, rebuild the furnace with air cooled walls and install a unit pulverizer.

Coal being used was from the local strip mine of the

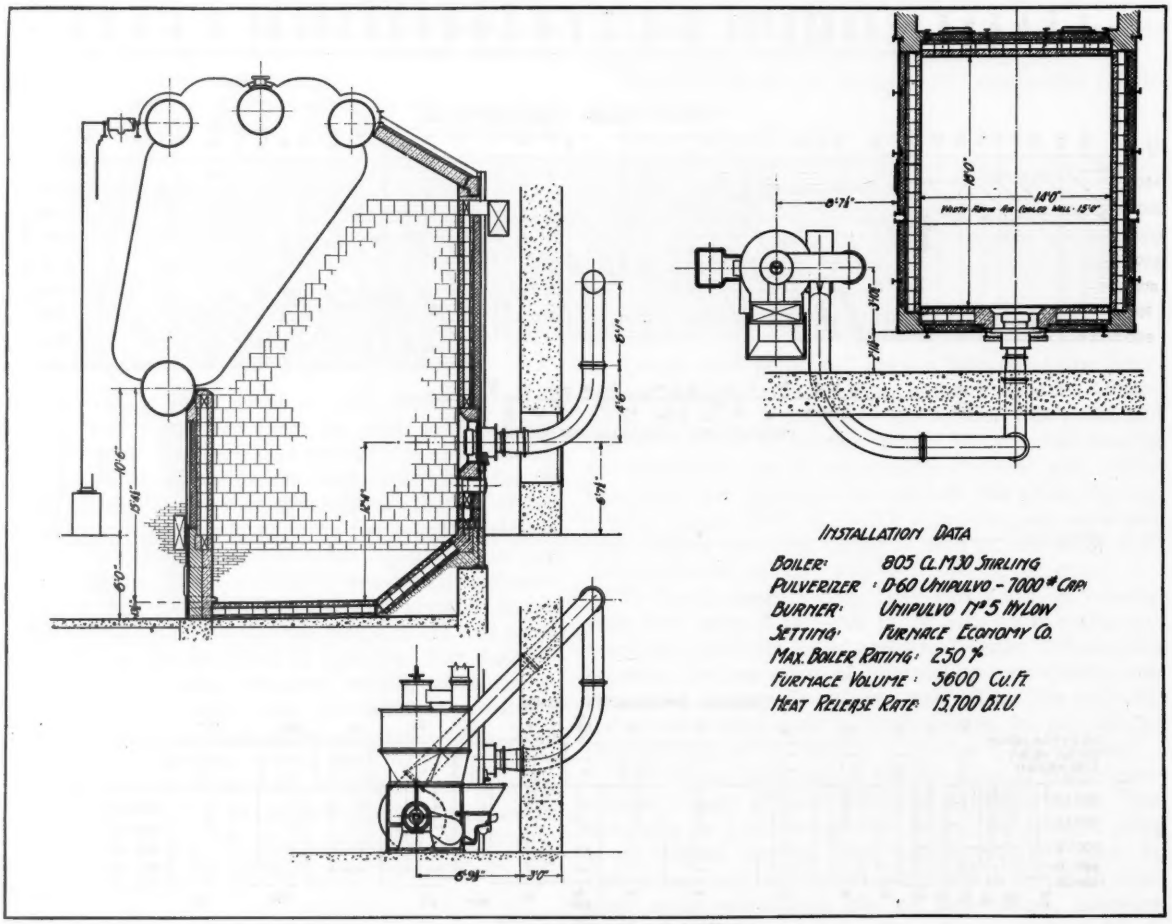

INSTALLATION DATA
BOILER: 805 CL. M.30 STIRLING
PULVERIZER: D-60 UNIPULVO - 7000# CAP.
BURNER: UNIPULVO TYPE S NY-LOW
SETTING: FURNACE ECONOMY CO.
MAX. BOILER RATING: 250 %
FURNACE VOLUME: 3600 CU. FT.
HEAT RELEASE RATE: 15,700 B.T.U.

FIG. 2. CROSS SECTION AND PLAN OF THE INSTALLATION. BECAUSE OF CLOSE QUARTERS THE PULVERIZED COAL DUCT TO THE BURNER HAD TO BE EXTENDED THROUGH THE COAL STORAGE ROOM.

Northern Illinois Coal Corp. The proximate analysis of a composite sample as reported by the Commercial Testing & Eng. Co. is in per cent: Moisture 14.05; ash 9.50; volatile 35.55; fixed carbon 40.90; ash fusion temperature 2050-2100 deg. F.; and by separate determinations; sulphur 1.59; and heating value 10,908 B.t.u. per lb.

In different localities, several attempts had been made to pulverize and burn this coal but with no practical success because of the high moisture content. More than usual interest was therefore evinced in this installation where, what was characterized as "the impossible" was successfully accomplished without difficulty.

The secret of the success lies in the combination of a large air cooled furnace which provides highly preheated air to the mill and a pulverizer through which all the air required for combustion can be drawn to assure sufficient drying effect to handle the high moisture content without condensation and sticking.

As shown by Fig. 1, the boiler was not disturbed but the furnace was deepened, enlarged and rebuilt with Furnace Economy Co. air cooled walls. As rebuilt, the furnace is 18 ft. long and 14 ft. wide, with a furnace volume of approximately 6700 cu. ft. The heat liberation at 250 per cent rating is 13,400 B.t.u. per cu. ft. of furnace volume. Through the extremely high heat dissipation of this wall, all of the air required for combustion is raised to approximately 470 deg. F.

The floor contains approximately 266 sq. ft. of Economy floor block and is used as a means of preheating secondary air which is admitted in the front of the furnace only when operating at highest rating. With 470 deg. F. to the pulverizer, the discharge temperature of the air-fuel mixture runs from 280 to 300 deg. F. With this high air preheat, the moisture content of the coal causes no decrease in capacity of the pulverizer or increase in the power consumption per ton of coal ground.

It is also of interest to note that the high heat transfer of the air cooled wall as indicated by the air temperatures obtained, causes an accumulation of fine porous ash on the walls, instead of molten slag and permits firing the furnace to be operated with high CO_2. The air-cooled floor has been found to be effective in the prevention of slagging on the floor. On one or two occasions during early experimental operating periods there was slag on the furnace floor, but this was always on top of 5 or 6 in. of fine granular ash and presented no difficulties in removal.

The pulverizer is a 7000 lb. per hr., Strong-Scott Unipulvo driven by a 100 hp., 1755 r.p.m., 220 v., 3 ph., 60 cycle General Electric motor. Limited space in the boiler room and the fact that the wall could not be altered because of the railroad track and coal hopper immediately outside, necessitated running the discharge pipe from the exhauster to the burner out through the wall, through the coal storage and return to the burner in the front wall of the furnace. There is about 35 in. clearance between the boiler front and building walls.

In addition, the new boiler is equipped with a Craig combustion control system, Cochrane flow meter, Ellison three pointer draft gage, Ashcroft pressure gage, Ranarex CO_2 meter, Yarway blowoff valves and a Brown recording thermometer. Two Worthington pot valve steam pumps are used for boiler feed.

Bunker C and Cracked Residues As Boiler Fuel

NEW OPERATING STANDARDS ARE NECESSARY IF DIFFICULTIES ARE TO BE AVOIDED WITH MECHANICAL ATOMIZATION. VISCOSITY AND NOT GRAVITY SHOULD BE USED AS GUIDE. BY T. B. STILLMAN*

DURING the past few years there have been some unusual and expensive experiences in burning Bunker C fuel oil in plants equipped with burners of the mechanical atomizing type. The author knows of no cases where exceptional difficulty has been experienced with steam atomizing burners using similar fuel. In order that all may understand just what Bunker C fuel oil is, the following is quoted from the definition of the Federal Specifications Board for this grade of oil: "It shall be a hydrocarbon oil free from grit, acid and fibrous or other foreign matters likely to clog or injure the burner or valves. Flash point, minimum by the Pensky-Martens closed cup tester 150 deg. F. Water and sediment, maximum 2.0 per cent. Viscosity, Saybolt Furol at 122 deg. F., maximum 300 sec."

The only difference between Bunker C and Bunker B or A fuel oils is the viscosity permitted at certain temperatures and the percentages of non-petroleum impurities allowed. It is important to note that there is no mention made in the specifications of the gravity of the fuel oil that may be sold under the different classes.

Several years ago the author's attention was called to a Bunker C fuel oil which showed unusual operating characteristics. The producers of the oil were called in and it was learned that the viscosity of this particular shipment bore no relation whatever to its gravity, and that with 175 F. oil temperature, proper viscosity for satisfactory atomization would be secured. The oil producers advised that the oil they were supplying contained a large percentage of residue from their high-pressure cracking stills.

One of the characteristics of these cracked residues in fuel oil appears to be their ability to continue to form flocculent carbon particles even when they are stored at relatively moderate temperatures.

Up to the time of the use of cracked residues in fuel oil sold as Bunker C, the author knows of no operating difficulties that occurred with a properly installed and operated mechanical atomizing oil-burner installation. The introduction of the cracked residues has, however, introduced an entirely new chapter. These residues are so unstable that if allowed to remain in storage an appreciable length of time they produce undesirable amounts of flocculent carbon which is a disadvantage both from the point of view of the oil-burning apparatus and the speed of combustion in the furnace. If the crude oil is an "acid-base" oil, lime is liable to appear

*Babcock & Wilcox Co. From a paper and discussions presented before the Metropolitan Section of the A. S. M. E.

in the residue burned as fuel oil with corresponding slagging of the furnace brickwork. If an operator has never burned a Bunker C fuel oil with cracked residues in it and is not advised to be guided by viscosity, rather than Baume or degrees A.P.I. in the heating of it, he is sure to have plugged heaters and atomizers.

At the same time it is to be kept in mind that fuel oils containing these cracked residues are inherently excellent fuels for power purposes, being high in B.t.u. value per gallon and should command as high a price as the older styles of Bunker C fuel oils. In spite of their relatively great density, their viscosity is low compared to the uncracked heavy grades of fuel oil, requiring less live steam for heating per gallon of oil burned, but the most important point of all is the fact that the percentage of cracked residues available for fuel oil is steadily rising and the supply of fuel oils from low-pressure stills is steadily decreasing.

At the present moment the author is inclined to feel that the oils in question should be suitable treated by the refineries previous to delivery to customers, not only to reduce the free-carbon content, but also to reduce the lime, ash, or other refractory-slagging impurities. Indications are that such a procedure is commercially feasible and it is to be hoped that it will keep pace with increasing output of such oils.

The following paragraphs are extracts from the discussion.

R. C. Vroom, Peabody Engineering Corp. It is desirable to mention the gravity of the fuel as well as its viscosity. A high gravity accompanying a low viscosity indicates that the fuel probably belongs in the class of cracked residues. Consequently, to produce the best results it may require treatment different from that necessary for the earlier forms of Bunker C, having the same gravity. For instance, certain of the oil companies are marketing a cracked residue of 2 to 5 A.P.I. gravity, but which requires practically no heating in order to permit its satisfactory mechanical atomization.

It would be well also to include in the specifications a figure for a temperature beyond which the fuel cannot be heated without danger of excessive deposition of carbon in the heater tubes, or in the atomizers.

G. A. Worn, The Lummus Co. In connection with the difficulty in heating oil in storage tanks to a satisfactory pumping temperature, the writer has found that the following arrangement gives very good results:

A sheet-metal tunnel is placed in the bottom of the tank large enough to enclose a hairpin coil. In horizontal cylindrical tanks the tunnel is built in longitudinally with the suction and butting against the end of the tank or closed off with light metal. The other end is open and extends to within about a foot of the head of the tank. The tunnel should be bolted to clips which are welded to the tank so that it can be raised for cleaning. The suction pipe is extended through the top of the tunnel to the usual distance from the bottom of the tank. All the oil is drawn through the tunnel over the coil to the suction pipe.

E. S. Hammond, E. S. Hammond, Inc. It has been found that in some cases heater coils have become so coated with asphaltum deposit that it was impossible to raise the temperature of the oil 20 deg. above the tank temperature with steam at 150 lb. pressure, whereas it had previously been possible to raise the temperature to 180 deg. with exhaust steam from the pumps. With the type of heater used by the writer, it is possible to clear up this trouble by injecting live steam into the oil compartment. Although at first it might appear that this would cause trouble at the burners, it has been found in practice that no objectionable effect is produced.

Lybrand Smith, Commander, U.S.N. A surprising point is the revelation that the engineer of any modern plant ashore or afloat used gravity instead of viscosity as a guide in heating fuel oil for mechanical atomization. Research at the Fuel Oil Testing Plant (the Navy's boiler laboratory) demonstrated that viscosity should be kept within the range 75 to 150 sec. Saybolt Universal, or 2 to 4 deg. Engler. The best over-all efficiencies are with about 120 sec. Saybolt Universal or 3.2 deg. Engler.

W. H. Osgood, Lieutenant Commander. The author brought out the fact that there is no specification covering the gravity of a fuel oil. As the writer sees it, there is no need for such an item, but as a point of possible interest, the calorific value has a straight-line relationship with the gravity of a fuel oil and therefore the gravity may be used as an approximate indication of the fuel's calorific value.

R. T. Goodwin, The Dorr Co. In utilizing a fuel oil made from cracked residues the fact must be kept in mind that this material is produced synthetically and has physical properties quite different from fuel oils produced from reduced crude. In producing a fuel oil from a reduced crude, the lower boiling and as a rule the more valuable products, are removed by distillation, and the non-distilled residue is the product used for fuel oil. In the case of a cracked residue, the charge stock to the cracking unit is usually a gas oil from 28 to 38 deg. A.P.I. gravity. This material under high temperature and pressure conditions is broken down to form lower boiling and higher gravity product, and a higher boiling and a lower gravity residue.

These fuels containing cracked residues are inherently excellent products for power purposes. Fuel oils from cracked residuums have a number of advantages so far as the consumer is concerned, such as, the viscosity is low for any given gravity; there is a rapid break in viscosity of a cracked product with increased temperature; we have found that this break usually occurs between 130 and 155 deg. F, a fact which results in a considerable saving in preheat of the oil; most cracked products will pour at 0 deg. F., while the uncracked fuels in some cases contain so much paraffin that they are solid at 60 or even 90 deg. F.; the B.t.u. contents of these two different fuels are about the same, with the exception that the cracked product is usually lower in gravity, with more pounds of fuel per gallon.

For several years the writer has been interested in the composition of cracked residuums and some method for controlling the precipitation of the solids which form the sediment content. We have found that by treating cracked residuums with a chemical the unstable hydrocarbons are precipitated as solids, so that the remaining oil is stable. In other words, in a few hours we do by chemical methods what it would be impossible to do in a number of months under storage conditions. This chemical treatment precipitates the carbon in a form which resembles carbon black, and carries with it any lime content of the residuum. The treatment removes from 5 to 30 lb. of carbon from each barrel processed. Carbonaceous material is removed by settling or filter.

Power Utilization

Motors—High-Speed Standard or Low-Speed Special

Short Center V-Drive Gives Low Cost of Equipment, High Power Factor, Good Efficiency and Flexibility of Arrangement.

By Walter A. Meyer*

TO A CONSIDERABLE extent the modern V-belt drive has contributed toward the elimination of need for direct-connected special-speed motors. Frequently, it permits the use of a high-speed, stock machine, whereas direct-connecting would require a heavier, more expensive special motor. On alternating current, the high-speed motor has better starting torque for a given horsepower, better efficiency and better power factor than the slow-speed unit.

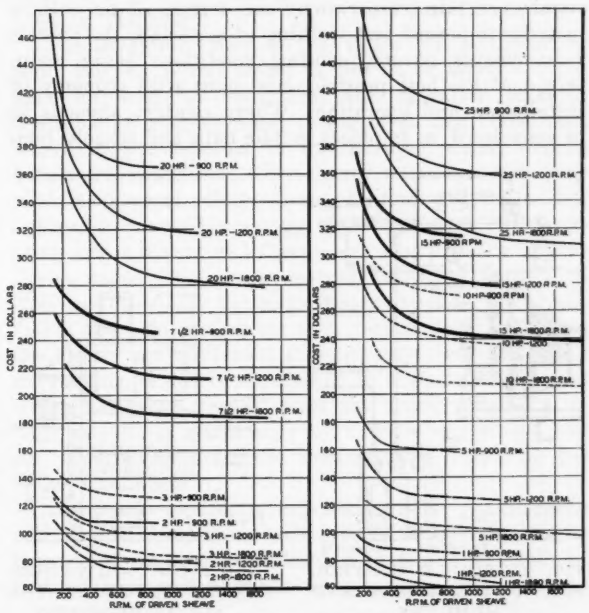
As to whether it is more economical to use a high-speed motor with a large-ratio speed reduction or a slow-speed motor with a smaller speed reduction, that the standard high-speed machine is more economical can be plainly seen from the accompanying chart giving combined prices of motors and V-belt drives for different conditions. The approximate combined cost of the motor and V-belt drive is plotted against the speed of the driven shaft or sheave in revolutions per minute. With the driven shaft speed definitely determined, it is possible to tell quickly what motor speed is most economical to use, or by subtraction to find the difference between any two given sets of equipment.

It will be observed that the total price of the equipment decreases as the speed ratio increases. In preparing this chart, current prices were taken, based on standard squirrel cage induction motors complete with starter and rails, all of which are required for the average installation.

To illustrate the point, if a given machine must operate at 400 r.p.m. with a capacity of 20 hp., the chart indicates that a unit could be furnished utilizing a 900, a 1200, or an 1800-r.p.m. motor; the prices of the different units would be $380, $350 and $320 respectively, showing that it is most economical to use the 1800-r.p.m. motor in conjunction with a large-ratio V-belt drive.

Economy that will result from employing high-speed motors instead of the low-speed units is not alone in first cost but, in the long run, operating saving is assured, inasmuch as high-speed motors mean higher power factor and in many cases increased motor efficiency.

*Texrope division, Allis-Chalmers Mfg. Co.


COST IN DOLLARS
R.P.M. OF DRIVEN SHEAVE
20 HP. - 900 R.P.M.
20 HP. - 1200 R.P.M.
20 HP. - 1800 R.P.M.
7½ HP. - 900 R.P.M.
7½ HP. - 1200 R.P.M.
7½ HP. - 1800 R.P.M.
3 HP. - 900 R.P.M.
2 HP. - 900 R.P.M.
3 HP. - 1200 R.P.M.
3 HP. - 1800 R.P.M.
2 HP. - 1200 R.P.M.
2 HP. - 1800 R.P.M.
25 HP. 900 R.P.M.
25 HP. - 1200 R.P.M.
25 HP. - 1800 R.P.M.
15 HP. - 900 R.P.M.
15 HP. - 1200 R.P.M.
10 HP. - 900 R.P.M.
15 HP. - 1800 R.P.M.
10 HP. - 1200
10 HP. - 1800 R.P.M.
5 HP. - 900 R.P.M.
5 HP. - 1200 R.P.M.
5 HP. - 1800 R.P.M.
1 HP. - 900 R.P.M.
1 HP. - 1200 R.P.M.
1 HP. - 1800 R.P.M.

COMPARATIVE COSTS FOR MOTORS WITH STARTER, RAILS AND V-BELT DRIVE

Changing the type or size of motor is much easier with the belt drive and accurate alinement is less essential than it would be with a coupled, direct-connected arrangement. Where speed reduction is slight, the cost of a V-belt drive is frequently no more or less than for a coupling, with the advantage of locating the motor in the most desirable position with respect to the driven machine.

UNDER AMERICAN Standards Assn., organization of a committee of engineers, architects and health officials has been requested by the American Soc. of Heating and Ventilating Engineers to submit recommendations for ventilation standards based on a comprehensive research as to effects of ventilation on health and comfort, now in progress at the Society's Pittsburgh laboratory. It is felt that municipal codes are based largely on tradition and one important result of scientific basing would be lowering of fuel bills by reduction of required outside air per occupant per minute to 10 cu. ft. Recommendations cover temperature, humidity, air quality, movement, distribution and quantity.

REVISION of simplified practice on wrought iron and steel pipe, valves and fittings has been accepted by the industry and will be put into practice as of Oct. 1 to eliminate 3½-in. inside diameter pipe from the double-extra-strong list. This applies to new installations and production of pipe, not to old installations.

POWER PLANT ENGINEERING October 1932

Air Conditioning

TEMPERATURE AND MOISTURE IN THE AIR REGULATED TO IMPROVE MANUFACTURING CONDITIONS AND INCREASE COMFORT OF WORKERS.* BY GEORGE B. BAILEY**

IN THE BROAD sense, air conditioning is addition or subtraction of heat and water vapor to or from air to secure a desired temperature and humidity. For industrial plants, where the process of manufacture requires certain temperatures and degrees of air wetness in order to permit best working of materials, the process requirements govern, comfort conditions being maintained at the best possible, consistent with economy of installation and operation. Where comfort alone is to be considered, as in offices, public halls and schools, temperature and humidity are regulated to that end, again keeping in view the matter of cost.

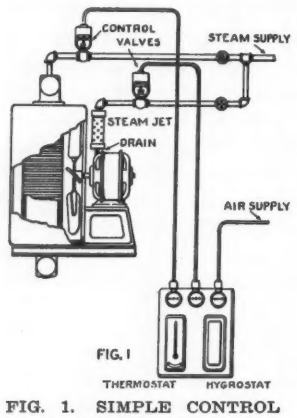


FIG. 1. SIMPLE CONTROL FOR TEMPERATURE AND HUMIDITY

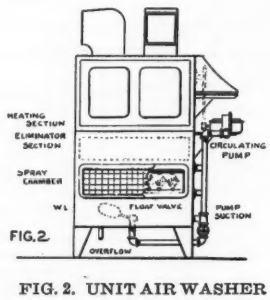


FIG. 2. UNIT AIR WASHER COOLS OR HEATS THE AIR AS REQUIRED

CLASSIFICATION OF SERVICE

Problems may be grouped as:

1. Moderate humidity and temperature, to be kept above given minimums.
2. High humidity with temperature above a minimum.
3. Low humidity with temperature held between given minimum and maximum.
4. Humidity and temperature to be kept practically constant at given points.

In group 1 a common problem is maintaining of humidity during the winter months, when heating reduces the per cent of saturation, since the warmer the air the more water vapor it can hold when saturated. One of the simplest ways to add water vapor is by a steam jet as in Fig. 1, which also helps to maintain temperature. Regulation of steam supply for the unit heater is by the thermostat and of steam jet supply for humidity by the hygrostat, each controlling the action of the compressed-air supply on its respective steam-control valve.

Other methods for humidity control are mechanical or air-jet atomization and air washing, relative cost being in about the order as named.

*From a paper before the National Process Meeting, Buffalo, N. Y.

**Thermal Engineering Co., Boston.

HIGH HUMIDITY

For group 2, addition of water vapor is usually needed summer and winter, as in a textile plant where humidity of 60 to 65 per cent is desired at about 75 deg. F. the year around. Here, too, the steam jet can be used in winter but in summer it adds undesired heat and causes discomfort. For summer, it is desirable to cool as well as humidify and atomization or air washing is found effective. In winter, however, the cooling effect of these systems is undesirable and involves use of additional radiation for heating. Obviously, air atomization supplemented by a steam-jet will be advantageous, in reducing radiation and the number of air-atomizing heads needed. Or the water to atomizers may be heated in winter, which will accomplish the same result.

Figure 2 shows an equipment adapted for this purpose, a unit air washer and heater. Use of cool water in summer and the heating section in winter gives the desired temperature to the water spray. Also the use of warm or hot water in winter increases the vapor capacity of air passing through the washer, enabling a small unit to handle large room volume and the large air volume mingles quickly with the room air to give uniform distribution of humidified air. A disadvantage of atomization is localized excessive humidity near the atomizer heads with possible condensation on pipes and machinery that are cooler than the air.

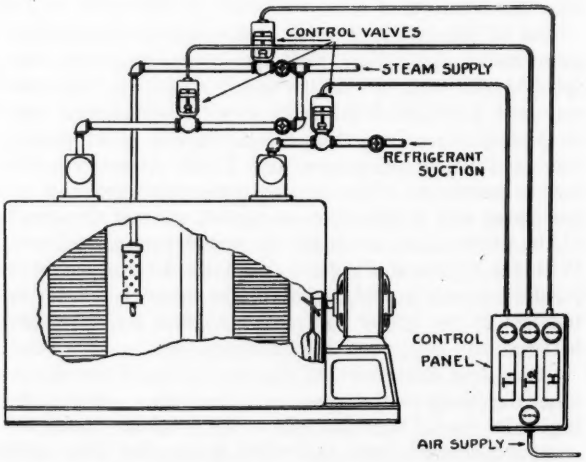


FIG. 3. THIS UNIT COOLS AND DEHUMIDIFIES AIR OR HEATS AND HUMIDIFIES IT AS DESIRED

LOW HUMIDITY

Group 3, in which are found candy factories, testing laboratories and plants where drying is carried on, need cooling of air to accomplish reduction of its moisture, sometimes followed by heating. In some cases, temperature must be held almost constant. In others a range of temperature is allowable, operation at the minimum in winter and the maximum in summer being best for economy.

Cooling and dehumidifying are by means of a unit cooler and air washer, heating by direct radiation or unit heaters; or a combined unit cooler and heater may be used as in Fig. 3. Cooling action may be by cold water, if an adequate supply is available but usually some form of refrigerating coil is necessary. The cooling throws down some of the water vapor as condensation thus dehumidifying the air, which may then be passed through the heating section or better through a separate heater if necessary. Heating and humidity regulation are by means of the unit heater and steam jet, the same as for Fig. 1. Control valves are operated by compressed air from the control panel by means of two thermostats, T_1 T_2 and a hygrostat H.

Moisture may also be reduced by passing air over silica-gel, calcium chloride, sulphuric acid or other material that has a high affinity for water. The method is used to advantage where extreme dryness is necessary and getting the low dew point that would be required by refrigeration would be too expensive.

Steady Temperature and Moisture Content

This requires cooling, heating, humidifying and drying of air, as external conditions change, to hold temperature and humidity within required limits. It is wise to allow as wide temperature fluctuation as possible, with humidity closely controlled, since the cost of exact temperature control becomes high when humidity must be held nearly constant. Printing, paper making and testing, rayon manufacture are some of the processes in this group.

Equipment of Fig. 3 may be used or an atomizer may replace the steam jet. The air washer of Fig. 2 may be utilized, with a cold water spray for cooling and dehumidifying and a warm spray for heating and moistening. But, if improperly used, this may become quite inefficient, wasting both heating and refrigeration energy.

In a recirculated air washer, with thermostatic bulb placed in the air stream where it leaves the eliminator plates and controlling water from the refrigerating source, the dew point of leaving air will be constant. If fresh air to replace room leakage is passed through the unit and sufficient volume of air is recirculated, the

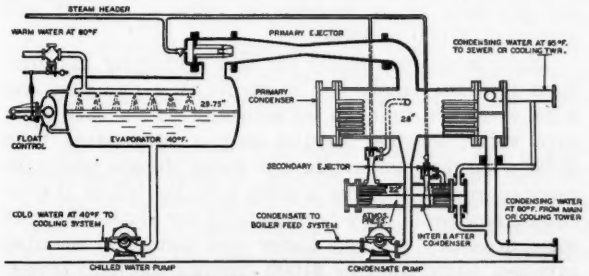


FIG. 4. STEAM JET REFRIGERATION GIVES SAVING IN DEHUMIDIFYING

dew point in the room under control will be nearly constant. Temperature is ordinarily controlled by a thermostat placed in the room to control steam to the heating coil and thus offset cooling in the spray chamber. Such an arrangement gives practically constant refrigeration load and on cool days a heating load, regardless of the fact that outdoor conditions may at times be almost identical with those maintained in the room, so that cooling and heating are unnecessary.

In large installations this may result in thousands of dollars a year wasted in operation. To be sure, the air is cleaned to some extent but at high cost and, in any case, if air cleaning is important, some form of filter is essential.

Refrigeration for Dehumidifying

Either direct or indirect application of refrigeration has been common. For the unit cooler of Fig. 3, a direct expansion coil may be best. If an air washer is used, a direct expansion coil is used to cool the water, or if well water at 50 to 55 deg. F. is available, that may be used to advantage.

Comparatively new is the steam jet refrigeration unit, Fig. 4. Where steam at 100 lb. or more is available, low cost for equipment and operation make it desirable in cooling water down to 40 deg. One case, where it was possible to use a dirty water with a barometric condenser, whereas city water was necessary with mechanical refrigeration, the first cost for a 75-t. equipment showed a saving of 40 per cent and operating cost a saving of 57 per cent. The primary ejector draws vapor from the evaporator, creating vacuum of 29¾ in. into which the warm water expands, the evaporation of a part cooling the rest. Steam and vapor from the ejector are condensed in a primary condenser at 28 in. vacuum, which is maintained by a secondary ejector whose discharge is to a secondary condenser at 22 in. This vacuum is maintained by another secondary ejector. Condensate from the condensers is drawn off for boiler feed water.

Automatic control is important in air conditioning and, properly applied, will give most effective maintenance of required conditions with minimum expenditure of heat and power.

Heater Condensate Drainage

For draining the condensate from a hot water storage-type heater or a feed water heater, ample provision should be made to remove the water as fast as formed and to prevent water backing up into the heater from the drain system.

Occasionally heater tubes may become loosened or split due to water hammer, usually caused by too small a trap, improper installation, or use of the wrong type of trap.

In one case, three water-tube heaters taking 130-lb. steam and drained by traps were installed to run on 24-hr. service from Monday to Saturday noon, then shut down over the week end. Starting up the second Monday, the operator reported severe water hammer when steam was turned on. The following week it was noted that the heaters were leaking badly and, on taking apart, all tubes were found loosened and bent.

Inspection of steam line, traps and condensation lines disclosed that check valves between heaters and traps had been omitted so that, when steam was turned off, vacuum formed in the heater shells and water from hundreds of feet of condensation lines was pulled back through the traps into the heaters. When steam was turned on Mondays, water hammer was severe until the shells were drained and two or three such hammerings ruined the tubes. Blame was put first on the heaters, then on the traps, when the trouble was due entirely to leaving out the check valves.

POWER PLANT ENGINEERING October 1932

Good Steam Trap Practice Pays

By Reginald Trautschold

NO STEAM power plant can be economically operated without a full and suitable complement of steam traps, properly located and maintained in efficient working condition. Not only are these accessories for drainage essential but they frequently effect such economies as to be the best revenue producers in the steam plant.

Kind of plant is a consideration, naturally, as are the respective amounts of steam used for power and heating purposes. A striking example of profitable steam trap practice in the paper mill field, where steam requirements for process operations are dominant and power is frequently generated as a by product, is the experience of an eastern paper mill having a daily output of about 15 t., chiefly wrapping paper and corrugated board.

Existing Conditions

Prior to this steam trap installation the beater wash water had been heated by the exhaust steam from the mill and approximately 80 per cent make-up water of distinctly scale-forming nature had been required for the two 200-hp. water-tube boilers serving the plant. This water, raised to about 212 deg. in an open type feed-water heater, was pumped to the steam generators operated at a gage pressure of 150 lb. The boilers furnished steam for an engine that drove a direct-connected generator and the exhaust from such power unit was used for paper drying and water heating, while the condensate from the paper driers was collected in a hot well and allowed to cool.

Direct heating of the beater wash water represented a loss of condensate, overheating when the wash water was not being utilized, and waste of steam. Loss of valuable heat also occurred from the evaporation of the drier condensate in the hot well and in the overflow from the hot well. Not only were these thermal wastes sustained, but the 80 per cent make-up water, the need for which was traceable in major part to the condensate losses, caused rapid accumulation of scale in the boilers, so that one of the boilers had to be taken off the line for cleaning at least every six weeks and, while the reconditioning of that unit was going on, the other boiler proved incapable of meeting the full steam demands of the two paper driers. This lack of available capacity kept half the mill in enforced idleness for the better part of a month, in the aggregate, each year.

So unsatisfactory was this situation, that serious consideration was given to the advisability of purchasing a third boiler, entailing an investment of $7000 to $8000, to supply sufficient additional steam for keeping the mill in full operation the year around. Instead of making that purchase, however, a modernization of the steam trap equipment then existing, whereby it was anticipated much of the cooling losses and avoidable waste of condensate could be eliminated, was decided upon. A system by which all the condensate from the entire mill is returned to the boilers and a heating coil employed to elevate the temperature of the beater wash water was installed.

Near the paper driers, a large pumping trap was placed, a few feet below the drier room floor level, into which the condensate from the driers, the beater wash-water heater coil and the mill heating system collects and is delivered to a second boiler return trap situated in the boiler room, some 100 ft. distant and located several feet above the boiler water line level. Condensate feed from the pumping and boiler return steam traps enters the boilers through the blow-off lines with no trouble in the division of water between the boilers. The amount of boiler make-up water required is small, necessitating only occasional operation of the boiler pump and heater. A few minutes at intervals of five or six hr. suffices for the replacement of all steam and condensate losses for the entire mill.

Individual steam traps formerly employed on the paper driers have been dispensed with, as a generously proportioned return line equalizes the terminal pressure and a steam supply line of adequate size provides uniform steam pressure at or to the paper driers. Returns from the drier line, from the hot water storage (wash water) heating coil and from the mill's heating system are collected in a receiver of good capacity, having a restricted vent, through a coil in which the vapors delivering the condensate to the pumping trap condense. Incidentally, practically all the steam employed in operating the traps is condensed in the traps, conserving all possible useful heat.

Economies Realized and Return on Investment

So successfully are heat losses prevented with this system, in fact, that the boiler feed water supply is maintained at a temperature of close to 282 deg. F., effecting a fuel saving estimated at 15 per cent. A like conservation of coal is attributable to the virtual elimination of boiler scaling, the untreated make-up water used having been reduced to a trivial amount. Together, these two substantial fuel economies represent a saving of close to 3500 t. of coal during a normal year of mill activity, or about $12,000.

Second only to this annual reduction in the coal bill burden is the value of the gain in productive capacity of the mill, effected by returning all condensate to the boilers with only negligible heat loss and by the indirect heating of the beater wash water. This totals in a good year to a production gain of approximately 4⅓ per cent, or an increase in value of annual mill output of $7000 to $8000.

Equipment responsible for this gratifying improvement includes simply two steam traps, a pumping and a boiler return unit, an oil separator and a back pressure valve, together costing only a little more than $1000; the pipe coil in the hot water storage tank; the receiver, reclaimed from a scrap pile, but which if purchased new could have been secured for about $60; and some necessary piping. Labor and incidental erection expenses added another $1000, making the total investment involved about $2000.

By the simple expedient of modernizing the steam trap system and practice in this paper-making establishment, the output of the mill was considerable increased, the purchase of the new boiler made unnecessary, and marked conservation in fuel realized, with an annual return of 600 or 700 per cent on the modest investment contracted. This is perhaps an unusual example of modern steam trap service, but so is the rate of return upon the cost of the undertaking. It emphasizes the advisability of every manufacturer and every oper-

ator of an industrial plant immediately investigating his steam trap practice and the suitability of the units he now employs for the essential service of condensate drainage. Modernizing his system and methods will cost but little, while the returns realized may readily be far more attractive than he imagines possible.

Air-Lift Pump Action

AS A RESULT of tests and analysis of results made at a German mine shaft, Dr. F. Pickert has derived the following relations as given in Engineering of London:

Submergence ratio being taken as depth of immersion divided by delivery height, for any submergence ratio, water handled increases with air supply, at first rapidly, then more slowly to a maximum, beyond which greater air supply gives less water flow.

Amount of water flow for a given air flow decreases with submergence ratio, a slight variation in the submergence ratio changing the variation of ratio of water delivery to air supply greatly.

Values from the tests were as below:

AIR-LIFT PUMP OPERATION

Submergence Ratio	Maximum Total Eff'y.	Best Ratio Water to Air
51.5	15.88	4200
8.33	41.14	1700
2.74	46.70	640
1.97	46.07	400
1.56	43.09	250
1.12	38.26	200
0.824	30,37	115
0.468	18.86	50
0.367	11.87	26

This is for a 1½-in. air pipe, a 4-in. riser and immersion from 135 ft. for highest submergence ratio to 37 ft. for lowest, lifts being respectively 2.6 ft. and 102 ft.

Efficiency of water handling is mainly determined by pipe friction and acceleration of the water flow. Air efficiency is affected by losses due to differenc in velocities of air and water. Analysis of results showed that, for a given submergence ratio, relative air velocity increased with weight of air used; for constant weight of air, relative air velocity increased with submergence ratio.

As to efficiencies, the water efficiency for a given submergence ratio is greatest at the most favorable operating condition as shown in the third column of the table. For low submergence ratios, air efficiency is nearly equal to total efficiency. Pipe friction losses approach a constant value at high loads but, for constant pipe length are greater in proportion to effective work as submergence ratio increases, as are also losses due to relative air velocity, which have a greater effect on overall efficiency than does pipe friction. For small pipe, with given submergence ratio, friction loss is greater but relative air velocity is less than for large pipes.

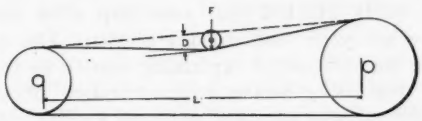
Practical conclusions to be drawn seem to be that good sized riser pipe, submergence ratio of 2.5 to 3 and water to air ratio of 500 to 600 are the best conditions for efficient operation.

Belt Horsepower Determined

BY THE following method a close approximation can be made of the horsepower required to drive any belt-operated machine, regardless of the type or material.

Given the simultaneous total tension on the tight side and on the slack side of a belt drive and the speed of the belt in feet per minute, it is simple to calculate the actual horsepower being transmitted. To determine belt speed is easy. The task is to find the belt tensions. But it *can* be done, as per the accompanying sketch, not only when a machine is standing idle but when it is in motion.

Press a light idler pulley against the mid-point of the belt as indicated until it deflects any convenient distance. Let us call the deflection D. Measure the force F in pounds required to produce the deflection, also measure the deflection D and the distance L between points of tangency on the pulleys in inches. For approximate computations L can often be assumed as the



distance between shaft centers in inches. To determine the belt tension multiply the force F in pounds required to deflect the belt by the distance L in inches. Then divide that product by D. The result is the tension on that side of the belt in pounds.

Do the same with the other side in precisely the same way. If possible, determine the tensions in the slack side and in the tight side simultaneously, as results will be more accurate.

Subtract the tension in the slack side from that in the tight side and the result is the effective pull in pounds.

Finally, to determine the horsepower transmitted, multiply the effective pull in pounds by the velocity of the belt in feet per minute. Belt velocity can be determined by referring to tables which are commonly found in standard handbooks and catalogs, or is 3.1416 d N, where d is pulley diameter in feet and N is r.p.m. of that pulley. Lastly, divide that product by 33,000. The result is the horsepower transmitted to the machine.

W. F. SCHAPHORST.

Use of Vacuum Pump to Exhaust Deaerating Heater—Correction

DUE TO a typographical error in the manuscript of the article under the above title on page 660 of the September issue, an unfortunate mistake appears. In the second paragraph the statement is made that "oxygen should be reduced to 0.001 c.c. per liter"; the figure should be 0.01 c.c.

TO MEET requests for information on lubricants and bearing testing machines, the Lubrication committee of the Petroleum division, A.S.M.E., is preparing a course of instruction for lubrication engineers, dealing with fundamental principles and their application to lubrication of all classes of machinery. The course is in the last stages of preliminary writing and, after acceptance by various trade organizations interested, will be available through the A.S.M.E., 29 W. 39th St., New York, N. Y.

POWER PLANT ENGINEERING October 1932

This thing called POWER FACTOR——

Part I. An informal discussion concerning the fundamental nature of Power Factor. In this first part, the Chief Engineer explains some of the basic principles regarding electric circuits preliminary to a more detailed consideration of the subject.

SAY, OLD TIMER, put your slip stick away and give me your undivided attention. I'm going to give you the pleasure of explaining something to me."

Val, the cocky young superintendent of the Still room, breezed into the chief engineer's office just as the latter was about to compile his daily report to the general engineering department.

"What! You in again? Why, you insolent young squirt—you'll *let* me explain something to you, will you? I presume I'm supposed to be overcome with joy. Don't you ever do anything except annoy people who are trying to work?" The chief assumed an air of indignation as he laid down his slide rule and leaned back in his chair.

"Work?" repeated Val, "Why you pampered office ornament,—you're a fine example to talk about work, why—"

"Now, now," admonished the chief, "calm yourself, don't get excited and tell me what's on your simple mind. I'll try to help you. With the help of the gods and some cuss words maybe I can pound some sense through three inches of solid ivory. But make it snappy, I've got more to do than act as tutor to a half-baked chemist."

"Oh yeah? Well, never mind the wise cracks, big boy, they are unbecoming to a man of your imagined importance. And just remember I'm too busy 'producing' around here to have time to waste rummaging through musty books; anyway that's what we pay bright technical experts like you for around here."

Say. Old Timer. put your slip stick —

"All right, all right; don't take it so hard. Just can the chatter and get down to business; and remember, I'm busy."

"That's fine, so am I. Well, then, tell me, what is this thing called power factor?"

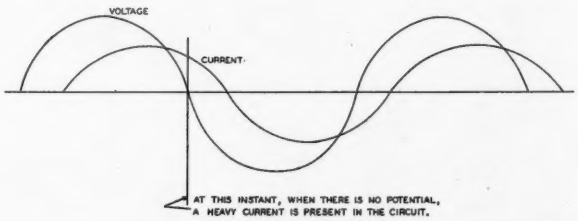


FIG. 1. IN THIS DIAGRAM, CURRENT IS SHOWN AT A TIME WHEN THE ELECTROMOTIVE FORCE APPEARS TO BE ZERO

"Power Factor?" echoed the chief with feigned astonishment. "Well, you are an ambitious young upstart. To think of a mere chemist understanding power factor! I suppose you would like me to draw a picture of it with crayons and disclaim on it with gestures!"

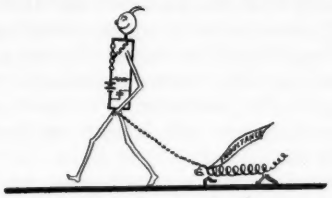
"Oh, no, big boy. Never mind the gestures, you're funny enough without them. Just take your time, only don't start slinging a lot of X's and Y's and Greek letters. I want to know what power factor is—what it does and where it hides in the circuit, and what wattless current is. Those birds that renew fuses on my motor circuits are forever howling about power factor and phase displacement, wattless current, or what have you and I'm about fed up on their chatter. None of them can tell me what it is all about—I don't believe they know themselves. Those electrical guys are a dumb lot anyway. So, now I'm coming direct to the fountainhead of all knowledge and wisdom for the right dope. Let's have the works, old boy; shoot!"

The chief threw up his hands in pretended disgust and then, resignedly, reached for a pencil and pulled a pad of paper towards him.

"Listen, young feller," he said, beginning to draw a few diagrams, "and look closely. I'm not going to waste my time on you for nothing. This is going to require at least the intelligence of a medium grade baboon, so you're going to have a tough time of it—but pay attention—maybe a little of it will sink in."

"As an old baboon to young baboon, I suppose."

"Before I start explaining these diagrams," began the chief, "let me tell you that this question of power factor is not as difficult to understand as most people think it is. If it were, I wouldn't be naive enough to attempt explaining it to a mere chemist; however, in order to understand it, you must first have a clear mental picture of certain fundamental principles in electricity and mechanics. As a matter of fact, that's where most of the trouble lies—in an inadequate conception of



fundamental principles. As a consequence the conception of power factor in alternating current circuits is one of the most confusing things in electrical engineering. Many who use the term and who calculate its effects by means of standard formulae often do not clearly understand what it means. To them, power factor is little more than an arbitrary term denoting abstract relations between current and voltage."

"That's right," chimed Val. "I'll tell the world. They tell me power factor is the cosine of the angle of phase displacement between something or other and they rave about reactive components but that doesn't tell me why I have to use larger fuses when the power factor is low. That's what I want to know, why do I need larger fuses when the wattmeters don't indicate any additional power."

"Never mind that just now," continued the chief, "we will come to that. As I was saying, there is a great deal of misunderstanding about power factor; not because the idea is fundamentally difficult to understand but because of the way in which it usually is explained.

"Take for instance this matter of 'wattless current.' We hear people talk glibly of wattless currents and power currents and some actually believe that two or more currents exist in the circuit at the same time. Now, this, of course, is just so much nonsense. At any instant there can be only one current or one potential in an electric circuit, a.c. or d.c."

"But why do they talk about wattless current and power current if that is so," interrupted Val. "Doesn't the wattless current exist?"

"Not actually—merely as an abstract conception. The division of currents or potentials into two or more components is purely a mathematical operation; it has no electrical or physical significance. You will find all this clearly explained in Croft's 'Practical Electricity.'"

"Is that a fact?" exclaimed Val. "Gosh, I'll have to look it up. I've got that book in my office, but I never seem to be able to find what I want in books. They talk all around the subject but they never get down to brass tacks. Power factor they say is due to phase displacement and inductance or the Democrats, but most of it is Greek to me. Why don't those birds write English?"

"Of course, you must understand, the books are written for intelligent people," ventured the chief sarcastically.

"Yeah? Well, how is it you can understand them then?"

The chief ignored Val's remark and half amused, half seriously, wondered how he could best explain away the difficulties. Finally, he asked:

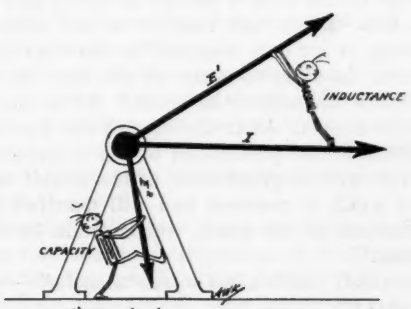
"Do you understand what is meant when we refer to a leading or lagging current or voltage, or rather do you know what these terms are supposed to mean?"

"Yes," said Val, "I think I do; that is I can see by means of diagrams how current and potential can be displaced from each other, but I can't visualize what this means in an actual circuit. Here, let me have your pencil." Val hastily made the sketch shown in Fig. 1. "For instance," he continued, "I have seen a great many diagrams of this type. Now, according to these there may be a heavy current flowing at a time when the potential is zero, or there may be no current at a time when an appreciable potential exists; well, maybe so, but I'm an Eskimo if I can see it. Furthermore, how can such currents (with no potential) produce heating and be indicated by ammeters? I asked Scotty, the electrician, about it the other day when he was raving about my load but he evaded the issue as usual. Anytime you can get anything out of a Scotchman."

"Well," said the chief, thoughtfully, "I'll try to explain these things to you but it will take time. First, however, I want you to get firmly in mind the fact that a current cannot exist without a potential (electromotive force) back of it, so to speak. No current can be entirely 'wattless' for some power always must be expended in overcoming the ohmic resistance of the circuit."

"But how do you explain these confounded diagrams—don't they show currents at times when there is zero potential?"

"Just a moment, we'll come to that; remember this is a monologue and you're supposed to be listening. I fully realize that the conventional diagrams, such as you have shown, depicting displacement between alternating currents and voltages often do not show all the components and the impression is gathered that currents exist in such circuits at times when the potential is zero. As I said before, this is impossible. If all the components of current and voltage were shown you would find that there is *always* an electromotive force *in phase* with the current. As a rule a number of components are left out of the diagrams to avoid confusion but in many cases such as your own, this practice only leads to greater confusion. However, there are other ways in which a conception of phase displacement and power factor may be obtained and that is by means of hydraulic or mechanical analogies.



Phase displacement is due to Inductance and Capacity

"Phase displacement, you probably know, is due to inductance or capacity in an electric circuit."

"Yes," said Val, "so they tell me, but that doesn't mean anything in my young life. You might as well tell me it is due to eating meat or to the gold standard. What I want to know is—"

"Hold on, now, don't get excited—I'm going to explain those things to you—give me time. To begin

with, inductance is a property of an electric circuit—not of the material of which the circuit is made, but of its shape or form. It is defined as that property of an electric circuit by virtue of which any change in current is opposed.

"This definition, you may note, sounds strangely like the definition of inertia in mechanics, which is as follows: Inertia is that property of a body, by virtue of which it (the body) tends to continue in the state of rest or motion in which it may be placed until acted upon by some force.

"Now, there is a very good reason for the similarity in these two definitions and that is that inertia and inductance are analogous."

"You mean that inductance is to an electric current what inertia is to a mechanical system?" queried Val.

"Yes, though not exactly. Inertia is the effect of mass and it is mass that inductance is equivalent to. Usually, however, we compare it to inertia because that is what impresses us in dealing with bodies having large mass. Therefore, the conception of power factor will be made easier if you keep the idea of inertia in mind.

"Let us take a flywheel for example. In starting a heavy flywheel energy must be applied not only to overcome the bearing friction, but also to overcome the inertia of the wheel. This latter energy, however, is not lost as is that expended in overcoming friction but is stored in the moving mass and can be made available when desired by removing the driving or accelerating force acting on the wheel. This stored energy manifests itself when the driving power is removed by continuing rotation and if the wheel is to be brought to rest quickly, additional power will have to be applied in opposition to the normal direction of rotation.

"Now, in an electric circuit containing inductance and carrying direct current a similar condition exists. When a switch in such a circuit is closed and current starts to flow, the current rises to its full value gradually. Energy is not only required to overcome the ohmic resistance of the circuit but energy also must be supplied to establish a magnetic field around the inductive portions of the circuit. As in the case of the flywheel, this energy given to the production of the magnetic field is not lost but will be given back to the circuit when the impressed e.m.f. is removed and will manifest itself in the production of an e.m.f. which tends to maintain the current."

"Gee, chief, that's a hot word, 'manifests'—where'd you get that?"

"Never mind about the word, young feller—just mind the power factor end of this discussion. That will be all that you can take care of. Do you understand so far?"

"Well, not entirely. You tell me that inductance is similar to inertia in mechanics, but I don't understand exactly why. Why is it necessary to establish the field first? When the switch is closed, don't the electrons, or the current in the conductors, or whatever it is start at the same time and at the same rate all through the circuit? Scotty told me the other day that a generator was nothing more than a pump for pumping electrons."

"Well," exclaimed the chief, "You do ask an intelligent question once in a while even though your capacity for learning is of a low order. I'll try to explain more fully but to do so we will have to go back to fundamentals. See this circuit?"

The chief indicated the diagram he had drawn, shown in Fig. 2A.

"This, as you see, is a simple circuit containing a lamp, a battery and a switch. Such a circuit we say has no inductance. Theoretically, this is not quite true as all circuits must possess a certain amount of inductance, but in this case it is negligible compared to the ohmic resistance, so we can assume that such a circuit has only resistance.

"Now, suppose the switch is closed suddenly—what happens? No, don't tell me, I'm explaining this. When the switch is closed the full potential of the battery is impressed on the circuit and since the resistance is constant, the current rises instantly to its maximum value, as shown by the curve, Fig. 2B. This is quite simple.

"Next let us consider this circuit. (Fig. 3A.) Here the lamp has been replaced by a coil, that is, an inductance. In this instance, when the switch is closed, the current does not rise to its maximum value instantly, instead it rises slowly as shown by the curve (Fig. 3b). This, we know, is due to the inductance of the circuit, but to understand the action more completely let us consider the forces (electromotive forces) acting in the circuit."

"That's the stuff, chief—I knew you could do it. Give me the low down on this inductance business and I'll give you the dope on the theory of phenolic resins or—"

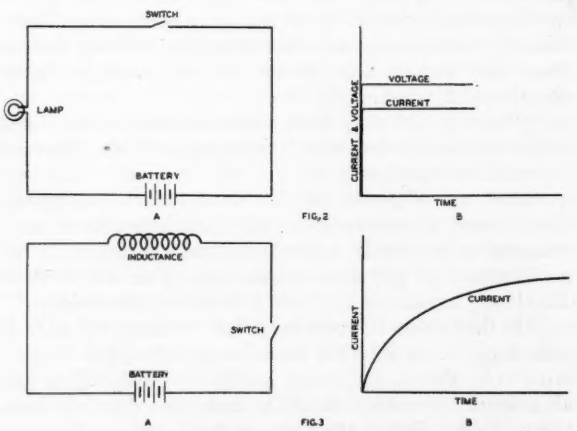


FIG. 2. THIS IS A SIMPLE CIRCUIT CONTAINING A LAMP, A BATTERY AND A SWITCH. WHEN THE SWITCH IS CLOSED THE CURRENT RISES TO ITS FULL VALUE INSTANTLY AS SHOWN AT B

FIG. 3. THIS CIRCUIT CONTAINS INDUCTANCE; BECAUSE OF THIS, WHEN THE SWITCH IS CLOSED, THE CURRENT RISES TO FULL VALUE GRADUALLY

"Never mind the theory of phenolic resins," interrupted the chief. "I don't care to know anything about it, but maybe you'll promise never to open up the steam lines on all your stills again all at once."

"Why, chief, you know I never did such a thing in my life. I—"

"Oh yeah? Well, alright, but let's be serious for a moment.

"When the switch in Fig. 3A is closed, as you say, current tends to flow in all parts of the circuit. Now a moving electric charge (an electric current) produces a field of magnetic force surrounding the conductor. The strength of this field is proportional to the value of the current. As the current increases, the lines (or circles) of magnetic force expand and in doing so cut the conductor through which the current flows. Now, we know that whenever a conductor is cut by lines of magnetic force, a potential is induced in that conductor. Also, when the conductor is arranged in the form of a coil or solenoid as in the diagram the effect is increased since the expanding lines of force cut adjacent turns. For this reason the 'induced' potential in a coil is always considerably greater than in the same length of conductor arranged in a straight line."

"You mean the more turns the higher the induced potential?" interrupted Val.

"Yes; in fact, the potential is directly proportional to the number of turns. Furthermore, the direction of this 'induced' potential is always opposite to the direction of the potential impressed on the circuit by the battery or other source of power. Because of this, it is called the counter-electromotive force. You see, it is like inertia in mechanics, it always opposes the impressed force on the circuit. See?"

"Yep, I get yuh, go on."

"All right. Now, another thing you've got to remember. The value of this counter-electromotive force is not a function of the strength of the current as is the magnetic field, but rather of the *rate at which the current is changing*. Therefore, there is no counter-electromotive force when the current reaches a steady value, but the instant the current increases or decreases, the counter-electromotive force appears. Now in Fig. 3A, at what point of time is the current changing most rapidly?"

Val scratched his head a moment, then ventured, "Why, at the instant the switch is closed, isn't it?"

"Right, now you're using your bean," exclaimed the chief. "The current is changing most rapidly at the instant the switch is closed, for at that instant the circuit is under the full potential of the battery and the current tends to rise to its maximum value instantly. Understand, I say the current *tends* to rise to its maximum instantly. Actually it does not, but the fact that this tendency exists brings into play a high counter-electromotive force and the current which actually flows is not that due to the impressed e.m.f. but that due to the combined effect of the impressed e.m.f and the counter e.m.f.

"Although I have put it that way, my last statement is not absolutely correct as I will explain.

"The counter-electromotive force does not necessarily oppose the impressed voltage, but it opposes what is known as the *induction component* of the impressed voltage. To show you what I mean by this, I have drawn these curves (Fig. 4). In this chart, the value of the impressed e.m.f. is shown to have a steady 'positive' value. At the instant of switch closure a portion of this impressed e.m.f. is required to overcome the ohmic resistance of the circuit and another portion, to overcome the effect of counter-electromotive force. This portion or component is called the induction component of the impressed electromotive force. The part required to overcome the ohmic resistance is called the energy component and this naturally is always in phase with the current. Now, since the value of the induction component at any instant must be the difference between the value of the impressed voltage and energy component, it is obvious that the curve of the induction component will have the shape shown in Fig. 4. The sum of these two curves at any instant, you see, is equal to the value of impressed voltage. Understand?"

"Fairly well, chief. I can't imagine just exactly

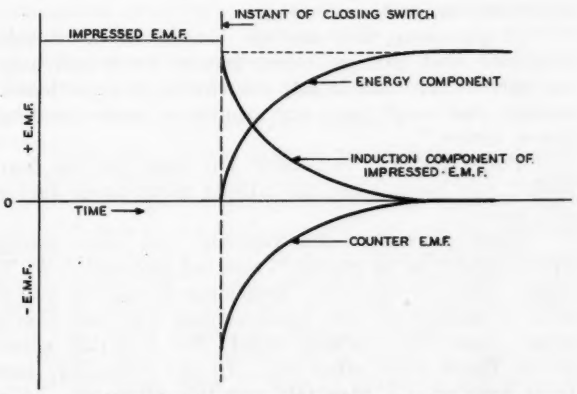


FIG. 4. THESE CURVES SHOW HOW THE IMPRESSED VOLTAGE MAY BE CONSIDERED AS BEING MADE UP OF TWO COMPONENTS, AN ENERGY COMPONENT AND AN INDUCTION COMPONENT

how these two components act in the circuit, but your diagram is clear. But what is that curve you have drawn below the 'zero' line?"

"I'm coming to that. First, just remember what I told you. *At any time there can be only one current flowing in a circuit.* And this applies also to electromotive forces. So even though I have drawn two e.m.f. curves (an energy component and an induction component) we know that there is only one electromotive force in the circuit—that is the energy component in phase with the current.

"The question then is: How do we get rid of the induction component? Well, the answer lies before you in the shape of the counter-electromotive force curve. The counter-electromotive force is always equal and opposite to the induction component of the impressed voltage. The algebraic sum of the counter-electromotive force and the induction component of the impressed voltage is always zero."

"By George, chief," exclaimed Val, "I'm beginning to see it now. Since the counter-electromotive force exactly neutralizes the induction component of the impressed voltage, the only electromotive force which remains is the energy component of the impressed voltage. Is that right?"

"Exactly. The counter-electromotive force always opposes the *induction component of the impressed voltage*, not the impressed voltage itself. This point should be definitely understood. The induction component of the impressed electromotive force used in overcoming

the effect of inductance—naturally the counter-electromotive force which is produced by virtue of the inductance must be always *equal* and *opposite* to the inductance component.

"Now, of course, I will admit that all this is easier to see on paper this way than it is to visualize what goes on in the circuit and so I suggest that you think of a mechanical analogy. Suppose, for example, you are trying to set a heavy car in motion by pushing it. The muscular energy you apply (the impressed e.m.f.) may be thought of as being expended in two ways, first (the energy component) to overcome the friction at the axles and at the rails and second (the inertia component) to overcome the effect of inertia, due to the mass of the car. The latter force you will note varies in accordance with the rate at which you try to accelerate the car. The inertia in this case is analagous to the counter-electromotive force.

"If you keep this analogy clearly in mind and remember that only one electromotive force and only one current can exist in any one circuit at a particular instant, you won't have any trouble in understanding power factor."

"Power factor?" exclaimed Val; why you big four flusher, you haven't told me a thing about power factor yet, how—"

"Calm yourself, calm yourself, you poor young squirt—don't get so excited," retorted the chief. "We'll come to that in due time. Remember I told you you'd have to understand the fundamentals first and that's what I have been talking about. We will talk about power factor some other day. In the meantime, just think over what I have told you this afternoon. In a day or two when it has sunk into that solid ivory bean of yours a little, come back and we'll talk about power factor. And now I've got work to do and remember, my boilers have other departments to supply besides the Still room."

(To be continued)

District Heating for Public Buildings in Washington, D. C.

CONTRACT for a steam distribution system to cost $1,250,000, consisting of 42,800 ft. of steam mains from 6 to 18-in. installed in 19,000 ft. of tunnel and conduit, has been let to Northeastern Piping and Construction Corp. on designs by United Engineers & Constructors. Work was expected to start the middle of August and be completed in a year. The power plant, not yet contracted, will be on C St. between 6th and 13th Sts. to serve a district bounded by 6th, E and 12th Sts. N. W. and C St. S. W. Design is for 300 lb. So far as possible joints will be welded and annealed and, after hydraulic test, reinforced by sleeves welded in place, extra heavy red brass pipe being used for inaccessible condensate lines as in conduit. Expansion will be cared for by slip and packless joints or by loops. Low points in the tunnels will be drained of seepage by electric-driven pumps. As some 50 per cent of the cost of the work is for labor, besides the labor for making pipe and equipment, the project is of the type to furnish maximum employment, also will be productive of future savings in fuel and care of buildings that will largely repay the cost. It is, therefore, in the class that President Hoover has advocated as desirable Government activity in building.

Polarity of a Solenoid

BY S. EIN

IRON PLACED in the magnetic field produced by a cylindrical coil will be attracted irrespective of the polarity of the coil. A common example, among many others, is the coil with an air core and, capable of moving within the latter, a cylindrical iron plunger. An illustration of this type is a coil mounted on one side of each of a row of 3500-kw. twin-tandem gas engines in a middle-western steel mill. When the coil is energized by the closing of a push button in the operators' room, its plunger rises and strikes the handle of a toggle switch controlling the ignition for one-half of the gas engine. The switch is opened and thus the generating capacity of the power station is reduced. In this manner, as many switches as are necessary are opened and the possibility that a sudden loss of some of the station's load will cause a quick rise in frequency and voltage is removed.

One of this series of coils had its leads disconnected to permit some work being done on the engine. Markings or tags were not placed on the leads of the coil nor on the wires to them. When the time came to reconnect the coil, the wireman in charge insisted upon making both of the two possible combinations of connections between the free leads and the coil ends. After each one was made, he listened to the "click" made by the plunger striking the handle of the toggle switch after the coil was energized. When this had been done, he claimed that the plunger struck harder with one set of connections than it did with the other one. He then made those connections permanent.

Because no harm was done, nothing was said. But, had he known, either one of the two possible methods, picked haphazardly, of connecting the wire ends to the coil ends would have done as well as the other. The reason is that irrespective of the direction of current flow through the coil—in at the top and out of the bottom or vice versa—the plunger will be attracted with equal force. Whatever polarity of poles appear in the magnetic field produced by the coil, poles of opposite, and thus correct, polarity will be induced in the iron of the plunger. Therefore, it will be attracted, rise and perform its allotted duty.

WHILE, during the period since 1929, realization has awakened in many industrial plants of the importance of economy in generation and uses of power, conditions have been such that many needed improvements have been deferred. As a result, much equipment in use is obsolete.

From many indications it would seem that an upturn in business is at hand, so that overhauling and re-equipment will be needed to meet increasing demands for goods. Equipment manufacturers have improved and developed their products to meet new conditions and secure greater economy in power plants and the use of power, so that, before undertaking rehabilitation, the power plant executive needs to become quite familiar with the new designs available and what they will do.

For this purpose, the National Power Show, to be held in Grand Central Palace, New York, offers exceptional advantages for collective and individual study of machinery and plant equipment.

Steam Piping Design and Specification for Power Plants

Preliminary Considerations, Calculations, Layouts, Boiler Room Piping, Engine Room Piping. Drawings and Specifications, Inspection and Testing. By Henry C. Moffett*

RARELY WOULD ANY TWO designers, given the same problem of laying out the steam piping for a proposed power plant, arrive at the same solution, yet the importance of correct design and the proper choice of materials may be appreciated by them both. Many different designs might be possible, all of them in accordance with the latest approved practice.

In order to visualize a piping problem, the designer should construct a diagram of the various lines. This diagram should show where lines begin and end, and what valves and specialties are required. It is usual practice to indicate all pipe sizes on piping diagrams, for the guidance of the detailer. One line diagrams are all that are necessary, and these may be either shown all in one plane or in three planes, usually isometrically.

Piping diagrams are based on heat balance calculations and flow diagrams, after it is decided what the cycle of operations is to be. Regenerative cycles complicate the heat balance calculations, and make the flow diagrams and piping diagrams more complex, yet one is complementary to the other, and they are often prepared at the same time.

After all calculations are made for heat balance, and the flow diagram prepared, the piping diagram may be further complicated by deciding to install loop systems, or double piping systems for the more important lines. Some utility companies go to extremes in this respect, but the tendency at present is to simplify steam piping systems as much as possible, since materials are better and the chances for forced shutdowns more remote. In some cases double valves in important lines have made double lines unnecessary or nearly so, and have cut the costs of piping down proportionately.

Frequently, in the progress of a design, it is found that lines are longer or shorter than was anticipated when the piping diagram was prepared, and so the pipe sizes must be corrected to suit conditions, otherwise pressure drops might be excessive or too large pipes used, thus making an uneconomical layout.

It is rarely possible to complete a piping diagram before the actual layouts begin, although most of the important steam lines should be diagrammed in advance. This is due to the fact that many of the smaller auxiliary pieces of equipment are not purchased until the piping design is under way. Engineers and purchasing agents should promptly decide upon and buy all units to which important steam lines are to be attached, as much time is lost waiting for certified prints. Manufacturers frequently will not furnish prints of their equipment until after receiving purchase orders, and cannot certify dimensions until they are checked for the particular machine to be shipped. This is likewise true for all but the simplest valves and specialties, and these therefore should be ordered from the diagrams.

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Preliminary Layouts

Preliminary layouts may be made before all major and minor equipment is accurately located in space, and tentative designs are frequently necessary to show clearances, as near as can be determined, prior to the starting of detailed layouts. Shifting of equipment is sometimes required in order to make room for the necessary pipes, and it is desirable, therefore, to carry all designs along with the piping design, as much as possible.

Much time and expense can be saved, in laying out important steam lines, if those in authority will make a decision and stick to it, instead of changing their minds frequently during the progress of a layout. In some cases such changes are justifiable, but for the most part it is evidence that sufficient thought was not given to the entire problem before giving orders to proceed.

A good piping designer does not make a layout until he himself has given the entire problem some serious thought, and has a picture in his mind of what the entire system will look like in space. Some designers never acquire this faculty, and are therefore forced to put something down on paper and frequently erase parts of their work .

On the other hand, some designs are so complicated that it is next to impossible to make a layout complete the first time. It is then necessary to make several layouts in order to pick the best path for the important lines and to eliminate the impractical ones. Preliminary layouts are valuable as they provide a trial for clearances and at the same time may be approved for arrangement before the details are gone into.

Steam piping in a power plant comprises all lines that carry steam or vapor at temperatures above that of the room. This includes a range of pressures and temperatures from the highest to the lowest in use at the plant, and these fall into several classifications according to these pressures and temperatures as covered by the American Standards. It is usual to start the design with the main steam piping, which is the highest, as the lines are more important and cost more per running foot. Such lines are given preference, as the shorter these lines can be, the more will be saved, relatively.

Divisions of Piping

Main steam piping is usually divided into two parts: steam lines in the boiler room and steam lines in the

engine or turbine room. In some industrial plants there is a third division consisting of the lines which may lead out of the power house to other buildings for process steam at full pressure. Frequently such lines are laid in tunnels, and difficult problems must be solved relative to expansion and anchorage in close quarters.

Boiler Room Piping

Boiler room main steam piping almost always consists of the leads from the boilers or superheaters to the main header or manifold, the main headers or loop, and the beginning of the leads from the header to the steam driven units. Sometimes an auxiliary steam header or loop is erected in the boiler room, but more often it is hung in a pipe gallery or in the basement of the turbine room.

The leads from the boilers to the header in the boiler room carry the hottest steam, therefore ample allowances for expansion should be made. It is customary to design boiler leads so that they bend into the header on top for drainage. If the leads are short this one bend is ample to take care of the expansion, but if the leads are long, expansion loops or other bends become necessary.

The main distributing header is laid on rollers more often than not, yet sometimes is hung on spring hangers. If all leads come in at one place, the header can be made short, and is then anchored down solidly. All such headers must be drained properly, and on high pressure lines this means that drainage controls or high pressure traps must be provided in order to rid the lines of condensation.

Boiler leads are invariably provided with non-return valves and gate valves, as called for by the A.S.M.E. Code. All designers should be familiar with these rulings, as the Code is used in part or in whole in the laws of many of the states. The gate valves should be located as near the main headers as possible and in accessible positions unless motor operated, as it is necessary to reach these for quick closing in case trouble develops in the boilers.

Other steam piping in the boiler room consists of leads through the roof from the boiler and superheater safety valves, soot blower steam supply lines, auxiliary steam piping to steam driven stokers and fans, and the miscellaneous drip lines leading to all traps.

Engine Room Piping

Main steam leads to the main generating units in the turbine room or engine room are brought up through the floor in the latest plants, rather than lead through the partition wall between the boiler room and the turbine room. This arrangement has a better appearance, and the piping is not in the way of the overhead crane. Many engineers insert large separators in each of these leads. If there is any danger of slugs of water being carried over from the boilers, this is a good precaution against damage to the blades of the turbine, or cracking a cylinder head on an engine. Many turbine plants have been built without these, where the steam is superheated sufficiently to insure against excessive condensation, and where the boilers are controlled in such a way that priming and overflowing is prevented.

Auxiliary steam leads to house turbines, steam driven boiler feed pumps, hot well pumps, ejectors and steam seals should be given preference over all other piping in the turbine room and made as short and direct as possible, at the same time allowing for expansion, by using bends and changes of direction wherever necessary. Other lines such as exhaust steam piping, atmospheric exhaust piping and drip lines, do not carry as hot steam, and are therefore secondary.

Drawings and Specifications

Final layout drawings, on which detailed designs are made should show all piping in plan, elevation and section, and when required for clarity, enlarged details inserted giving complete information as to what is intended. Piping plans cannot be too complete, and many details are better than too few. Nothing should be left to the imagination of the bidder, nor to the erecting contractor. All connections to equipment should be detailed, and the complete specification of the joint set down on the drawing, even though it is standard.

All drawings should be accompanied by piping specifications when sent out for bids on the material or erection. This should contain first a complete list of the drawings that it refers to, giving the last date of issue. If before actual contracts are let, revisions have been made on the drawings, such changes must be made in the specifications.

Specifications should be complete in themselves, or refer to drawings for details not mentioned. They should state the pressure and temperature of the steam to be conveyed by each system of pipe, and set down the requirements for each element of each system.

If walls are to be cut for the passage of pipes, it should state who is to do the cutting. If excavations are necessary, it should cover who is to do the work. Statements should be included as to sidetrack facilities, and for the storage of materials prior to erection.

The specifications should cover the kind of fittings for each line, whether screwed or flanged in a range of sizes, the material and physical requirements of each, and whether or not they should be heat treated. If this falls into a classification covered by one of the American Standards as adopted, it should be so stated.

In like manner, flanges are to be covered, and a statement made as to the facings desired. There are many kinds, and the choice is with the engineer. Studs, bolts and nuts must all be specified, and definite requirements made known.

If it is possible to include a complete list of all the valves and specialties, it is best to do so, giving all the necessary information available to insure that no substitutions will be made. If a particular make of valve is decided upon, state the maker's name, as valves are not standardized except as to face to face dimensions, and minimum thicknesses, and even these are not always identical.

It is necessary also to include a table of pipe sizes and thicknesses, and to state the kind of pipe wanted, whether seamless tubing or lap-welded. Some engineers go so far as to state the pipe maker's name, especially on very high pressure jobs.

Unless all the hangers are detailed on the drawings, the specifications should include a table giving the minimum dimensions for hangers on different lines, and a statement setting forth the physical characteristics of the steel to be used. Spring hangers should always be detailed, unless some particular manufacturer's product is wanted, so that it may be referred to as to catalogue number or drawing number.

All gaskets should be specified, both as to make and thicknesses. If metallic gaskets are called for, state whether corrugated or plain. State also whether gaskets are to cover just the facing of the flanges or are to extend to the bolts.

Specifications should also cover the painting of fittings in the shop, if the engineer believes that they should be, or to leave off all paint so as to make inspection easier. If flashings are to be furnished where pipes pass through roofs, state who is to furnish and install them.

Pipe covering specifications are usually separate from the piping specifications, since such covering is usually let under a different contract. However, if it is to be included with the piping, it should be mentioned in detail and all the necessary information included. Thicknesses should be stated for each line and size of pipe, the kind of material to be used definitely set forth, and schedules included giving the kind of outside dressing to be used, and how the covering is to be held onto the pipes. There are many kinds of covering and the coefficients of thermal conductivity differ considerably.

After all the detail drawings are completed, and the specifications prepared, quotations should be sought from all reliable piping fabricators and covering manufacturers. Bids submitted will vary over a wide range, although the clearer the specifications are, the closer the quotations will be to one another.

Some piping fabricators will enter into contracts for erection of their own material, while others will not. It is for the engineer to decide whether it will be best to let the entire contract to one concern, or to split it up into several contracts. There are advantages and disadvantages both ways.

Erection of important steam piping is a specialty in itself, and can not be done successfully by just any steam-fitter. It requires special skill, and experience. It is therefore best to let some organization experienced in this branch of the business do the erecting, as the results are much better. Poor erection may injure important piping beyond repair, and usually is more expensive in the end. Quite often, due to the manner in which designs are rushed out, many field pieces are required, and it is necessary to take field measurements for such pieces. Many erecting superintendents are not qualified to take these measurements accurately, and it is necessary to call in some manufacturer's erector to insure a perfect job.

Inspection and Testing

After all steam piping is in place on a job, and before the insulation is applied, it should be tested for leaks. Common practice is to apply hydrostatic pressures two and one-half times as great as the steam working pressure. If a job stays tight at this pressure for four or five hours, it is deemed satisfactory, and should remain tight under the normal steam pressure. Careful inspection should be made to detect poor materials, but if shop inspection has been rigid, none of the parts should have to be replaced after erection.

Some designers and erectors purposely plan to give all steam piping an original strain by pulling up bends and long offsets, knowing that after the steam has been turned on, these strains disappear as the pipes expand. It is also true that, even if strains are set up due to expansion in such lines, after some time has elapsed, the systems adjust themselves and all stresses are equalized. This is particularly true when the designs are such that no solid anchorages are installed.

Steam piping is a very important part of power plant design, and should be given due consideration along with the choice of all equipment. Remarkable economies can be made by proper designs, and lamentable failures have been made by delegating piping to inexperienced and poorly paid assistants. As working pressures continue to rise, this is more clearly the fact, and engineers are beginning to understand that it does not pay to slight this part of the job.

Troubles Eliminated by Steam Purifiers

Statements Gathered From Industrial Plants Point Out That Scale Formation in Superheater Tubes and on Turbine Blades May Be Entirely Prevented By Use of Steam Purifiers. By C. E. Joos

NOTEWORTHY experiences which the writer has had with steam purifying equipment in different sections of the country where the value of such equipment has been clearly demonstrated are outlined below in the form of statements from engineers responsible for operation in the various plants. Unfortunately, the policy prevailing in some plants forbids revealing the identity of the plant but the author takes full responsibility for all unsigned statements as he has been consultant on all of the installations cited here. The compilation of this material was suggested by the request published on page 395 of the May 1 issue of Power Plant Engineering.

Plant A*

Increased load imposed upon this boiler plant, together with the high concentration of solids in the feedwater resulted in a severe foaming and priming condition. The condition was so severe that a number of superheater tubes became completely choked up with solids and failure ensued and it was necessary to replace some tubes and turbine out the remainder for removal of deposits.

Steam purifiers were placed between the boiler outlet and superheater inlet and as a result of the complete removal of the moisture and sludge from the steam, no further failures of the superheaters occurred, nor was it necessary to turbine them free of deposits. They remained clean. As another result, the turbines and other motive power equipment showed improvement in economy of operation.

Plant B

Because of high amounts of moisture carry over, this plant was confronted with the problem either of extending boiler plant in order to operate the boilers

*C. E. Underwood, Bethlehem Steel Co.

at lower ratings to produce dry steam or of installing steam purifying equipment for the protection of turbines against deposits.

One steam purifier installed for test purposes was found by test to deliver 100 per cent dry steam and as a result the entire boiler plant was equipped, the results of which have been entirely satisfactory, eliminating turbine blade deposits and permitting the boiler plant to be operated at a rating sufficiently high to carry the load without the addition of more boilers.

Plant C

We do not have superheaters so our steam purifier is placed in the main steam line between the boilers and the turbine. This has been in use for about 4 or 5 yr. and has been opened up about twice in that period. No dirt, scale or mud was found in the purifier, having passed out through the traps. Before this installation, slugs of water came over with the steam which naturally had a tendency to cut the blades on our turbines, but this condition has been cleared up by the purifier, and we are satisfied with its operation as far as our turbine is concerned.

This moist steam also hindered the heating of the calender rolls and paper machines before installation of the purifier—since then this condition has shown a marked improvement.

Plant D

In connection with the operation of waste heat boilers at 250 lb. pressure, wet steam resulted in high maintenance cost of turbines due to rapid erosion of the blades. A test on one of the steam purifier units installed to correct this trouble indicated the delivery of absolutely dry steam, as shown by the table.

	Inlet Purifier					Outlet Purifier					
Time	T_1	T_{1a}	T_2	T_{2a}	% Mois.	OT_1	OT_{1a}	OT_2	OT_{2a}	% Mois.	Trap Dis.
2:23	392	397	304	303	0.5	397	386	315	314	0.0	
2:25	392	397	300	299	0.9	397	386	315	314	0.0	
2:27	392	397	295	294	1.2	397	386	313	312	0.0	
2:29	394	399	397	296	1.1	399	388	313	312	0.0	Start
2:31	394	399	217	216	+5.0	399	388	313	312	0.0	
2:33	396	401	214	213	+5.0	399	388	313	312	0.0	
2:35	394	399	214	213	+5.0	399	388	315	314	0.0	
2:37	394	399	284	283	1.7	399	388	315	314	0.0	
2:39	394	399	297	296	0.9	399	388	313	312	0.0	Stop
2:41	394	399	300	299	0.8	399	388	315	314	0.0	
2:43	394	399	302	301	0.7	399	388	315	314	0.0	
2:45	394	399	300	299	0.8	401	390	315	314	0.0	
2:47	396	401	297	296	0.9	401	390	315	314	0.0	
2:49	396	401	244	243	4.1	401	390	315	314	0.0	Start
2:51	396	401	233	222	+5.0	401	390	315	314	0.0	
2:53	396	401	239	238	4.5	401	390	315	314	0.0	Stop
2:55	394	399	217	216	+5.0	399	388	315	314	0.0	Start
2:57	396	401	244	243	4.1	399	388	313	312	0.0	
2:59	396	401	289	288	1.7	401	390	315	314	0.0	Stop
3:01	396	401	300	299	1.0	401	390	315	314	0.0	
3:03	396	401	302	301	0.9	401	390	315	314	0.0	Dis.

Plant E*

Prior to the installation of the purifier, a discharger and hot process softener, frequently slugs of water carried from the boilers to the engines caused damage in our uniflow engines, to the connecting rod bearings, the valves and to the cams and cam rollers.

Inasmuch as our engines drive generators furnishing the current to our factory the power service was unreliable; at times without warning we were shut down completely.

Since the installation of this equipment there have been no shut downs from these causes.

*George Palmer, The Gerlach-Barklow Co.

Plant F

The steam load at this plant is subject to wide variations, from 80,000 lb. to 210,000 lb. within five minutes and dropping back to 80,000 to 90,000 lb. in less than ten minutes. As a result of operating the steam generator at 1000 per cent of normal rating, there is severe moisture carry over, which has resulted in clogging up the blades of the turbine so badly that it was necessary to wash the turbine free of these deposits each week-end. The installation of steam purifying equipment overcame this condition and entirely eliminated all cleaning operations in connection with the turbine. It has also eliminated superheater tube failures and deposits, which were previously experienced.

Plant G

This plant experienced unbalancing of the turbine rotor due to accumulated deposits within the hollow shaft and on the blading, resulting in expensive repair costs and entailing reblading the entire rotor following stripping of blades because of this unbalancing.

The trouble was traced to impure steam and purifiers were installed, resulting in complete protection against deposits and assurance against loss in carrying capacity of the steam turbine. This installation is significant in that instead of blowing down the boilers through the regular blowoff, concentration is taken care of by allowing the boilers to prime, recovering the heat from the purifier traps by means of flash and heat exchange apparatus. Thus, the purifier combines a complete automatic continuous blowoff system with a positive assurance of dry steam.

Plant H**

This is a chemical manufacturing plant, using large quantities of pure distilled water in the manufacture of high grade chemicals and drugs. Until recently, distilled water was produced by triple effect evaporators, but due to insufficient capacity for present demands, consideration was given to purifying the steam before its entry to the heating systems, and using the condensate return as distilled water. This plan was impossible of carrying through without purifying equipment, due to the contamination of the steam.

The installation of purifying equipment produced such an excellent quality of steam that the condensed steam, subsequently filtered, showed no trace of boiler water impurities and is satisfactory for the preparation of chemicals. This installation takes the place of an expensive evaporating installation, which otherwise would have been necessary.

**Chas. B. Llewellyn, Merck & Co.

Installation of new boilers and modern power equipment and construction of additional power housing facilities at its Kenvil, New Jersey, explosives plant, is announced by Hercules Powder Co. $135,000 has been appropriated for the project which will proceed at once, according to George E. Ramer, the company's chief engineer. Two new 500-hp. steam boilers, with auxiliary equipment will be installed in a new steel building immediately adjacent to the present engine room of the plant, also a new turbine for high-pressure steam. It is stated that the improvements are being made at this time because of the present low prices of materials, labor and equipment.

The mechanical problems involved in extending the application of movable blade runners to high heads are small compared to the hydraulic problems. Hydraulic whirl, the author points out is an important factor and an equation is presented which expresses the whirl law. The equation should be useful in correctly proportioning movable blade runners.

High Head Hydraulic Turbines with MOVABLE BLADES

By
John S. Carpenter

LOW HEAD WATER TURBINES with movable blades have effected substantial operating economies in comparison with fixed blade runners under the same physical conditions. The movable blade runner presupposes some form intimately allied to the propeller type, having no outer band and usually four blades.

The noticeably weaker hold, upon the hub of the movable blade runner as compared with the fixed blade runner, gave much concern, at first, as regards strength; therefore, its use was confined to the lower heads for some time. While fixed blade runners have been used for some time up to heads as high as 80 ft., for a long time movable blade runners were not offered for heads higher than 30 ft.

Operating economies are such that the field of the movable blade runner should be extended to 100 ft. head, at least. Above 100 ft. head, the part load efficiencies of water turbines usually offered for such heads, begin to approximate the results given by movable blade runners. The prospect of gain, due to the use of movable blade runners under such conditions, is overshadowed by the high cost of movable-blade turbines.

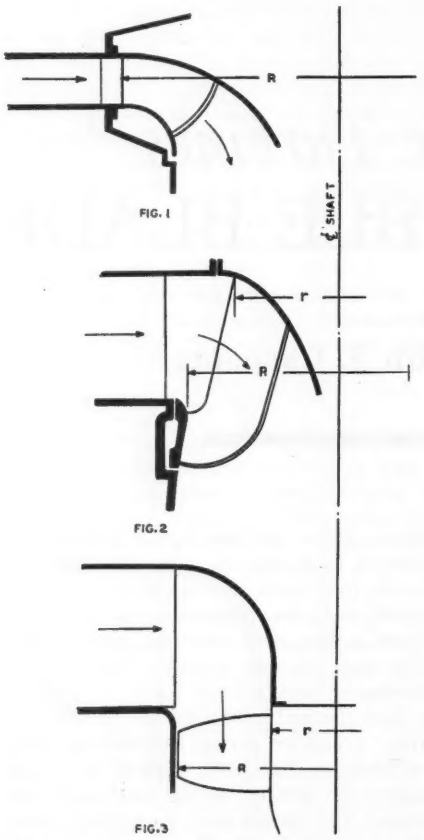
Problems confronting the builder in extending the field of the movable blade runner are of two kinds; mechanical, as regards strength; hydraulic, as regards efficiency and durability. With heads even as low as 30 ft., the use of cast steel runner blades is practically dictated by strength requirements, using hubs 3/8 of the maximum runner size, in diameter. The mechanical problems, in this effort to extend the field to 100 ft., shrink to almost nothing compared to the hydraulic problems. This does not mean necessarily that the field cannot be thus extended, but it means that builders will be obliged to give far more study, in design, to problems whose surface has been barely scratched up to now. For example, up to this time, the differences in pressure between the inner and outer radii of the blade have not been considered; the pressures due to primary whirl, centrifugal action, and traction forces have not been studied to any adequate extent. Runners, so far, have been developed largely by cut and try methods. Quite a large field lies untouched by the research it deserves. Too often, a runner giving satisfactory results as regards efficiencies, has been allowed to go into plants. Fortunately, on account of the reasonable heads so far encountered, the results have been fairly good; only in exceptional cases has there been serious trouble. When higher heads will be applied to the movable and fixed blade runners, the effects of pressure differences, as above enumerated will be more readily apparent and the destructive effects of high velocity water will point out where further study is needed.

As further study and testing, along these lines, proceeds, it will be found that appreciably larger diametered hubs are dictated; but not by strength requirements so much as by hydraulic whirl conditions at runner entrance and exit.

In order to get an insight into the hydraulic conditions which have so important a bearing upon efficiency and durability of the water turbine runner, be it of the pure radial, mixed radial and axial, or pure axial flow types, it is necessary to show the family portraits in the order of their appearance upon the stage. Figure 1 shows the pure radial type, in which the whole runner entrance diameter is constant. Figure 2, the mixed flow type, shows a variation in entrance radius from r to R. Figure 3 shows the axial type; a still greater variation of entrance edge radius.

In Fig. 1 the water meets the entrance edge of the runner with whirl components only in one plane, with respect to the rotational axis. In Fig. 2, a transition space introduces axial flow besides some radial flow. In Fig. 3 the flow is almost entirely axial.

The fundamental turbine equation can be reduced to $e\ g = u_1\ c_{u1} - u_2\ c_{u2}$; for 1 ft. head quantities, where e is the hydraulic efficiency, a decimal, less than unity; g is the gravitational constant, 32.2; u_1 and u_2 are peripheral speeds of runner vane edges at entrance and exit points, respectively, in ft. per sec.; c_{u1} and c_{u2} are absolute tangential whirl components of water at the peripheral points considered.



FIGS. 1-3. THREE TYPES OF RUNNERS IN GENERAL USE, 1 RADIAL TYPE, 2 MIXED FLOW AND 3, AXIAL TYPE

In plain words, the above quotation tells us that the algebraic sum of absolute tangential whirls cannot possibly exceed 32.2. A great deal of testing experience has convinced the writer that the exit whirl can be assumed as zero for one point on the runner exit edge only. This will be found to be the radius at which the primary whirl becomes the constant value for the entire entrance edge. The products of primary whirl and peripheral speed will then be found to be uniformly increasing from inner to outer blade radius.

Starting with the differential equations of Euler and Zeuner, the writer derived relations showing the value of the above cited zero exit whirl radius in terms of the maximum diameter of runner. Twenty years ago, when this solution was offered, the writer often heard heated discussions as to what radius of the entrance edge of a type like Fig. 2, then coming into wider use, the fundamental equation was to be applied. It will be seen that the type of Fig. 1 brings up no such question as u_1 is constant.

That this matter of hydraulic whirl is of extreme importance in high speed movable blade runners for higher heads, we shall see as time goes on; especially in the durability of such runners and their "outage" records. It does not necessarily follow that an efficient runner will be a durable runner, particularly under higher heads. The writer has in mind a runner, showing excellent efficiencies for its specific speed, that, under a microscope, showed spots and scouring on the leading face of the blade after only a few hours' run at the most efficient point. The entering water sheet had broken away from the entrance edge at that point. Larger runners of the same stepped-up model showed pitting at the same proportional points.

Tests made by the writer over a period of 6 yr. in an excellently equipped hydraulic test laboratory gave ample proof that the whirl law deduced by the writer was correct. It may be stated that the radius to which the fundamental equation applies, as indicated in the foregoing, varies from 75 to 90 per cent of the maximum entrance radius, according to profile.

The correct progression of whirl variation from r to R, in Fig. 3, will produce durable movable blade runners of good efficiencies at heads as high as 100 ft. and still keep down runner pitting to a small quantity. Measurements on quite a few installed fixed blade runners have shown that the entrance angles at many points along the entrance radius are not correct.

Pitting of the exit portions of such runners is caused principally by the water failing to follow the blade curvatures, due to centrifugal action. In such cases also, microscopic examinations have shown spots and scouring where the water sheet broke away. When conditions were corrected, these were stopped.

Considerations of pitting, then, will merit careful attention as higher heads are applied to both fixed and movable blade runners. Coupled with this is a new consideration. So far as pump and turbine runners are concerned, water has heretofore been regarded as incompressible. When blade pressures, in certain portions of the runner, of several thousand pounds per square inch are to be faced, the condensations and rarefactions of water compression will require serious study.

An example will be interesting, of a 10,000 hp. turbine under 100 ft. head, running at 225 r.p.m. Using a fixed or movable blade runner, to satisfy the whirl conditions, a hub diameter 60 per cent of the maximum runner diameter, is required. At 25 ft. head, a hub 38 to 40 per cent of the runner diameter is adequate.

Using high strength steels, the vane actuating levers, links, and crosshead can be got inside the runner hub.

Without question, both front and back sides of the vane or blade must be machined to templet. The bumps and hollows of ordinary mold swell and distortion unquestionably have caused serious pitting.

In order to reduce pressure concentrations, vanes or blades for high head runners should be longer and of more gradual curvature than for lower heads.

If some fair method of paying a bonus to the builder for low outage time or freedom from serious pitting were to be adopted, it is believed that builders would go into these worthy matters in a much larger way. The benefits would accrue eventually to all concerned.

Readers' Conference

Turbine Vibration

TURBINE VIBRATION, especially during the starting period, is not uncommon and can be caused by different details of the turbine design or the arrangement of piping equipment and steam chest. Many of the difficulties, however, can be traced directly to improper warming up and the importance of this procedure should not be overlooked. Before starting, the machine should be thoroughly warmed up and with superheated steam it is possible to overdo this phase and get uneven heating which causes distortion and consequently vibration. Even warming is impossible while the rotor is standing still because the hottest steam will remain at the top of the casing falling to the bottom as it cools. Neither the spindle or the casing will then be straight and the spindle will run out of true as soon as it is started.

In the old days with saturated steam the machine could be warmed up standing still for saturated steam does not stratify because there is little or no change in density as the steam gives up heat. With superheated steam this stratification does take place so it is best to warm the chest but a few minutes and then get the spindle turning as quickly as possible at low speed. The throttle should be opened quite rapidly until the spindle moves and then closed slowly until there is just sufficient steam flow to keep it moving.

With water sealed glands the turbine should be started up noncondensing and not subjected to a vacuum until the spindle is revolving fast enough to seal the gland. This type of gland is nothing but a small centrifugal pump and is not effective until a fairly high speed is reached. If a vacuum is put on before the gland is sealed, air will be sucked in around the shaft unevenly and may result in distortion of the shaft.

After ten or fifteen minutes (or even longer on big machines) the spindle can be gradually brought up to speed passing quickly over the critical speed point. When almost up to speed the gland water should be turned on. Vacuum can then be built up although unless it is desired to build up the load at once it is best to maintain a low or moderate vacuum for awhile.

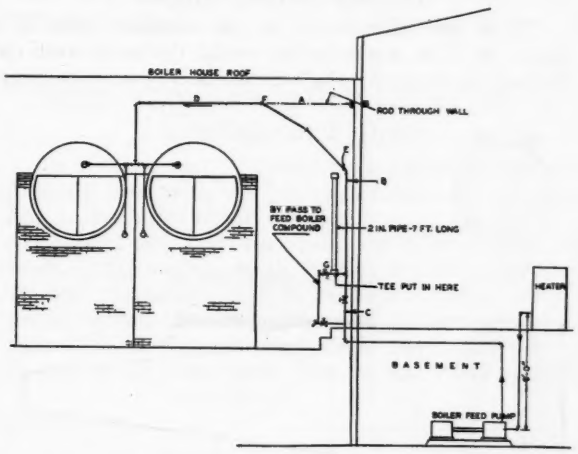
When shutting down, the vacuum should be broken as soon as the throttle is closed and before the machine slows up sufficient to unseal the glands and let air be drawn in past the shaft. The gland water should be shut off so that there is no danger of it leaking over into the bearing or pedestal oil reservoir to mix with the oil.

Brooklyn, N. Y. P. F. ROGERS.

Air Chamber Cures Feed Line Trouble

IN THE SKETCH is shown the general idea of the layout of our heater, boiler feed pump and boilers though all of the twists and turns of the pump discharge line are not indicated. The pump room is under the engine room and the heater is on the engine room floor level, which gives us a 9 ft. head from bottom of heater to pump.

Although the pump had operated satisfactorily without undue noise or vibration of feed line to boilers for about 12 yr., the other day the feed line, which is anchored to the wall at points B and C, began to jump and kick at every stroke of the pump, moving away from the wall in the direction marked D. The hammering of the pump was extremely annoying and the jerking of the pump threw all the strain on the 45-deg. ell and joint at E, which was so great that there was danger of something breaking. A clamp put around the pipe at F and an eye bolt A long enough to reach through the wall with a long thread, so that large washers and nuts were put on each side of the wall and tightened, stopped the movement but the hammering



FEED LINE CONNECTIONS WHICH GAVE TROUBLE

was transmitted all over the shop and caused a lot of complaint.

At the first chance the pump was overhauled and all checks and other valves gone over but still the hammering continued. At last we put in a tee as shown at G and ran a piece of 2-in. pipe up the wall 7 ft., capping it on top. This formed a sort of an air chamber which has completely eliminated the trouble.

Minneapolis, Minn. FRED S. RUTLEDGE.

Properly Planned Equipment

GUESSWORK on equipment needed often "gets by" but more than occasionally trouble will eventually develop and a department, or possibly the entire plant, may be shut down for hours.

On motor jobs, the required motor size should be determined by careful calculation or from comparison with other similar jobs or, better yet, from actual tests made with a temporary set-up. Overheated motors, as well as underloaded motors, will thus be eliminated as well as consequent troubles and power losses.

Belts, chains, pulleys, shafting and other transmission equipment should be carefully chosen for the speeds and horsepowers to be transmitted. There seems to be a tendency in some plants to use whatever may be

easiest obtained, rather than that which will safely carry the power being transmitted.

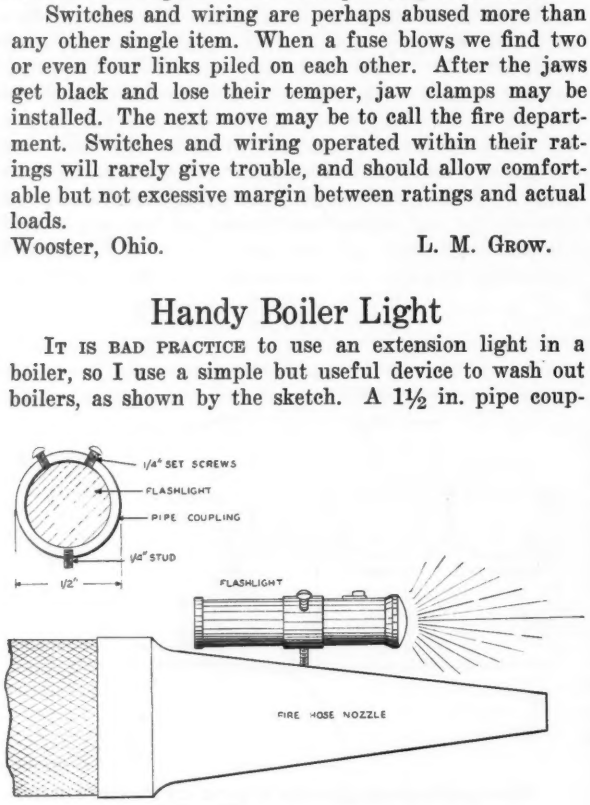
Centrifugal pumps and air compressors should have proper characteristics as to pressures, suctions, capacities and efficiency. Impellers designed for the existing operating conditions will be most efficient and cannot, therefore, be shifted from one application to another without due regard to the new operating conditions.

Switches and wiring are perhaps abused more than any other single item. When a fuse blows we find two or even four links piled on each other. After the jaws get black and lose their temper, jaw clamps may be installed. The next move may be to call the fire department. Switches and wiring operated within their ratings will rarely give trouble, and should allow comfortable but not excessive margin between ratings and actual loads.

Wooster, Ohio. L. M. Grow.

Handy Boiler Light

It is bad practice to use an extension light in a boiler, so I use a simple but useful device to wash out boilers, as shown by the sketch. A 1½ in. pipe coupling is attached to the fire hose nozzle by means of a stud. A flashlight fits in the pipe coupling and is held fixed by two set screws as shown in the drawing. This device gives plenty of light just where it is needed and allows the free use of both hands.



FLASHLIGHT FASTENED TO NOZZLE

Orange, N. J. Wm. H. Deeley.

Causes of Excessive Grate Maintenance

Many causes of excessive cost of maintenance of cast iron grates under furnaces and boilers have been observed by the writer in his rounds as boiler inspector. Most of these cases indicate poor management on the part of the operators.

Grates should be purchased of a foundry that makes a specialty of grates and uses a special quality or mixture of iron to make it heat resisting. Grates should be designed to conform to the type of fuel being burned. They should be well ventilated in structure with stiffening ribs and plenty of air spaces to keep them ventilated and cool as well as to furnish the air necessary for combustion.

For instance in plants burning wood refuse and sawdust, it is common to use herring-bone grates. Perchance the supply of shavings and sawdust runs short and they must burn a little slack coal of poor quality which clinkers and runs the narrow interstices in the herring-bone grates full of slag. Unless this slag is removed so as to restore the ventilation, about the next time there is a heavy fire in the boiler the grates will overheat and become warped. It should be part of the regular routine in boiler cleaning to inspect the grates and remove any accumulated slag which seals up the interstices in the grates. This is generally done by use of a cold chisel or some special tool made for that purpose.

Burnt grates are most commonly caused by allowing the ashes to accumulate in the ashpit until they are solid up to the grates. When ventilation from below is thus cut off, it is only a matter of a short time until the grates are burned or warped so as to make them unserviceable. This is an occurrence that often happens to green firemen.

Often unskilled firemen burn their grates in the following manner: they are supplied perhaps with a grade of slack coal containing sulphur and iron pyrites which clinkers and "pancakes" down onto the grates shutting off the draft. These heavy clinkers should be found and removed but if the fire is merely turned over with the bar these same clinkers melt the second time and run down into the interstices of the grates, effectively sealing off the air supply to the fire. By looking into the ashpit from below one may locate the dark spots on the grates where they are stopped and with a bent poker can often loosen the clinker from the grate from below, and locate and pull out the slag from above. Thus by careful firing of bad fuel one may often save the grates from being burned.

Grates of the shaking type are excellent to keep the fire broken up when poor fuel is used. This type of grate is often injured by having the fingers burned off on account of the firemen forgetting to level off the grate after using the shaking bar.

The writer often finds that grates are burned in spots by improper banking of fires in boilers that are idle part of the time. The fireman cleans a spot leaving the grates bare, then piles onto this spot a bed of live coals, then throws on top of this about 6 or 8 in. of fine slack coal patting it down solid at the top thus stopping the flame entirely from the top. The result is that gases are distilled downward into the ashpit and catch fire there. This inversion of the fire makes the grates redhot and burns a hole in the grate that the fireman is often at a loss to account for. Often the fireman will bank his fire on the deadplate of the boiler just inside the firing door. This generally ends in warping the dead-plate. I would prefer to place my banks back near the bridge wall, to have several inches of ashes on top the grates to protect them from the live coals, not to have too thick or too much fine coal in the bank, to leave a little flame bursting through the bank so that the fire will not become inverted, to leave fresh coal alongside the bank so that the fire will progress sidewise and leave plenty of fresh coals to start a fire. If properly done fires can be banked without injuring the grates.

In this connection I wish to state that grates are sometimes cracked or warped by some one throwing a drain bucket full of half oil and half water into the furnace. A dash of water onto a hot grate is sure to crack it. I knew of a fireman who picked up a shovel full of coal that had a large icicle on it. This icicle

hit the hot grate and cracked it. To secure long life of grates, keep liquids out of the fire, keep ash pits well cleaned out, keep clinkers removed from interstices of grates, keep fires clean and be careful how you bank your fires.

Logansport, Ind. C. C. CUSTER.

Gasket Blowouts

IN A CENTRAL STATION started up some time ago steam was generated at 1400 lb. pressure and superheated to 750 deg. F. Considerable trouble was had after starting the plant with gaskets blowing out at the flange joints of the main steam lines. The gaskets were to be of the metallic serrated type. Quite an expense resulted from the forced shutdowns for gasket replacements, as to run long with the steam blowing at this pressure would probably result in cutting the flange faces.

After some study it was decided that the expansion rate of the studs was enough greater than that of the flanges to cause a slight loosening at operating temperatures. The pipe insulation was then permanently removed from all the pipe flanges and they were protected by nothing but a coat of aluminum paint. After this was done gasket replacements due to blowouts were practically eliminated. It seems that the studs being exposed to the air circulation keep at a slightly lower temperature and as a result keep the joint tight. While radiation losses are higher with the flanges uncovered they are much less than the cost of frequent shutdowns.

West Roxbury, Mass. HARRY M. SPRING.

Increasing Efficiency of Oil Heater

AS A SUGGESTION which may be of interest to your readers I am presenting an interesting experience regarding the operation of oil heaters.

Recently in our steam plant of three 400-hp. boilers the underfeed coal stokers were removed, the furnaces enlarged from 800 cu. ft. each to 1200 cu. ft. and an oil burning installation made.

The oil system consists of a 30,000 gallon tank, placed underground, to which crude oil is supplied by truck. The tank is supplied with a heating coil and oil is fed by gravity through a 4 in. line to the boiler room. Two motor driven oil pumps are installed, together with two straight tube vertical oil heaters. The heated oil is delivered through meter and strainers to four mechanical burners per boiler. With the use of the natural draft available the installation is guaranteed to produce 800 hp. per boiler and the oil system is designed for 2500 hp. The oil heaters were designed each one to heat this full quantity of oil to 250 deg. F., using 100 lb. steam pressure.

On starting up the system only fair results were accomplished due to the inability of the heaters to heat the oil properly. With loads of about 1200 to 1400 b.hp. full steam pressure of 125 lb. had to be used and temperatures of oil could not be raised over 245 deg. F. At times this temperature would drop to 225 deg. F. when excessive pulsations would result in the furnaces.

The heaters were carefully examined and tested. These were divided into three passes by means of partitions in the heads. Temperatures taken of the oil at the end of the first pass showed as high as the final temperatures produced at the end of the third pass. The natural conclusion at first was that by-passing was occurring by the end partitions. Close examination indicated a possibility of this occurring so the heaters were removed, baffles in ends rewelded and the heaters reinstalled.

The results on starting up again were so nearly identical with the original results that another cause was evident. This was attributed to the possibility that with the low rate of flow many of the heater tubes were stagnant with only a few being actively in service. The suggestion was made to try out placing twisted flats in each tube to increase the resistance through the heaters.

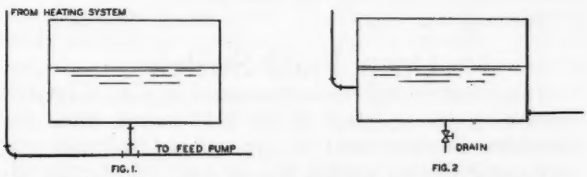
These twisted flats were installed and the heater operation at once improved. Temperatures of 250 deg. F., incoming oil being 160 deg. F., were obtained with 50 lb. of steam pressure. These flats are made longer than the tubes so they may be removed when cleaning the tubes.

This experience was interesting as the oil and the installation were not at all unusual, yet similar results had not come to the attention of the heater manufacturers in a large number of similar installations.

Wilmington, Del. LEWIS H. HAUPT.

Surge Tank Operation Improved by Change in Piping

IN A PLANT that I recently visited a surge tank was formerly used with the piping arranged as shown in Fig. 1. With this layout practically all of the oil which was carried over from the steam engine by the exhaust steam simply made a circuit through the heating system, the feed pumps and back to the boilers, where, after a period, considerable foaming and priming took place. Very little of the condensed steam would flow up the up-take to the surge tank. The piping system and the



FORMER AND REARRANGED SURGE TANK PIPING

boilers would occasionally have to be blown down and flushed out to remove the accumulated oil, thus necessitating considerable periods of outage as well as inconvenience and expense. After some time of this procedure it was decided to change the piping to a system as shown in Fig. 2. With this arrangement most of the oil would float to the top of the tank in its passage from inlet to outlet. By skimming the surface of the water or by the use of absorbent paper the oil could be removed. Also, because the outlet of the tank was placed above the bottom, any particles of scale, etc., would settle to the bottom, thus removing all large particles from the feed-water. A drain pipe at the bottom provided for flushing the surge tank.

Since the change the plant has operated without any inconvenience or shut-down. Although this system of pipe layout requires a few more fittings, it is obvious that the elimination of the oil trouble was well worth while.

Westfield, N. J. GORDON R. HAHN.

Plant Operation Problems

Why Did Polarity of Large Generators Reverse?

F. V. GREENE of Brooklyn asks a rather puzzling question in the August 1 issue. The iron circuit may not be of sufficient quality or the size of frame may be insufficient to retain the small amount of residual magnetism.

The small generator may be close enough that it would affect the larger machine when it is shut down. The larger machine would be affected more readily by the fact that it is shut down while hot and heat tends to neutralize the magnetism. The inherent residual magnetism may be weak. If this should be suspected it would be a good idea, say every 4 months, to raise the brushes on the large generator and close the switch or some form of connections to reinforce the magnetism.

More probably the remedy is to check brushes for neutral and to check distance from toe of each brush to heel of the next, all the studs being checked in this manner. They should all be the same number of bars apart. The brush position affects the weak residual magnetism to a great extent.

It may be that the small engine vibrations tend to dissipate the residual magnetism while the larger machine is shut down at night. I have heard of cases where the earth's magnetism affected the generator adversely, but am not familiar with the phenomena.

After the generators were arranged for parallel operation it is possible that the larger machine could have been thrown on the line with low voltage or too much rheostat cut into the field circuit.

Birmingham, Ala. G. H. EMERSON.

Open Field Switch

IN REGARD TO the recent discussion in your magazine concerning the opening of the field switch when the alternator is under load, in my opinion, the unit will over-speed, due to sudden loss of load. Then, the alternator, acting on the principle of an induction generator, will feed power into the line. As the field circuit is open, the amount of power generated is problematical.

This reasoning is based on an actual occurrence of several years ago, when the field switch of a large hydro-unit was accidentally opened.

It is unfortunate that this happened so long ago that I do not remember the actual details. I do remember distinctly, however, that we did not lose the station, and that the main generator switch was opened before exciting the alternator again.

I would not recommend closing the field switch until the alternator is off the buss. The alternator would certainly be out of phase, more or less, and, in the case of a large unit, out of phase excitation might possibly produce disastrous results.

Would like to read of an actual instance of the field switch opening accidentally and would be interested in knowing the amount of over-speed, and the amount of power produced by the un-excited alternator.

Central Islip, L. I., N. Y. WILIAM SHEFFER.

Economic Turbine Rating

IN AN article by Professor A. G. Christie he says, "Many turbines are now purchased with most economical load at 60 per cent of rating." How is this done and is it practical to change the most economical point of an existing turbine? J. W.

A.—Any manufacturer can furnish turbines for the most economic load at 60 per cent rating if specified in the order. All that is done is to make the blades and nozzles in the primary section such that they will pass the steam to develop 60 per cent rating. Additional capacity above this point is secured by admitting steam through secondary and tertiary nozzles. This has been done on the larger turbines such as those at Milwaukee, Waukegan, Hellgate, East River, but I do not believe that it would be commercially practicable on small units as their mechanical losses are relatively higher. This is fixed in the design of the unit and once a turbine has been built it is not possible to change the most economic point. A. G. CHRISTIE.

Motor Bearing Lubrication

IN ANSWER to C. J. of Peru, Ind., whose question appears in the August 1 issue, I would like to say that suitable greases for ball and roller bearings are manufactured by nearly all of the larger lubricating companies.

Housings of ball bearing motors are usually provided with closely fitting covers on the outside and around the shaft on the inside is placed a felt and one or more grooves to prevent creepage of lubricant. The most common cause of this trouble is putting too much lubricant into the housing in the first place, also using a pressure gun on bearings. It is not necessary that the bearing cavity be filled for the bearing to be well lubricated. About one-third full, generally up to the lower side of the shaft with the front cover of the bearing removed, is the most satisfactory amount to have in a bearing.

Grease is commonly used for ball bearings, but oil also may be used. Generally, where oil is used, grease may be substituted with satisfactory results. The grease should not flow freely enough to impede the balls and thus generate heat. It should not be so hard that it will not melt or flow after a few minutes operation. Ball bearing grease should not contain impurities which might attack the balls or races.

One filling of a bearing should last for six months to a year according to service and I have known them to operate for longer periods than this. When filling, all old lubricant should be removed.

Birmingham, Ala. GRADY H. EMERSON.

FROM THE CHARGE and discharge currents of any dielectric under continuous potential it has been found possible recently to predict accurately the loss, power factor and capacity of the same dielectric at 60 cycles alternating potential.

Engineers' Week in Milwaukee

MANY ENGINEERING SOCIETIES COÖPERATING AT GREAT LAKES POWER CONFERENCE, SEPT. 5-10, HELP N.A.P.E. CELEBRATE THE GOLDEN JUBILEE COMMEMORATING 50 YR. OF ASSOCIATION SERVICE TO THE OPERATING ENGINEERS OF AMERICA

ENGINEERS' WEEK in Milwaukee centered around the Golden Jubilee of the N.A.P.E. commemorating the Fiftieth Anniversary of the organization of the society in New York, 1882. In common with all organizations, the past year was a trying one but under the able leadership of National President Lisle A. Pierson of Detroit, a new spirit of coöperation and enthusiasm was evident and in spite of conditions eight associations reported increases in membership and received the customary flags, the last that will be given as prizes.

Evidence of this spirit of coöperation is seen in the results of the elections of national officers. In contrast to the usual many sided contests of local factions, the officers with one exception were filled this year by unanimouse vote on the first ballot. Albert F. Thompson, Mo. 3, was elected president; J. A. Prudell, Wis. 1, vice-president; Fred W. Raven, Ill. 1, secretary; Samuel B. Forse, Pa. 1, treasurer; Horace W. Wilds, N. Y. 1, trustee; C. E. Chapman, Utah 1, conductor; Robert Craig, Cal. 1, doorkeeper.

The one exception to the unanimous election was in connection with the election of national trustee for a 5 yr. term. The first nominee, W. J. Reynolds, N. J. 5, and former president of the board, in the face of vigorous protests from the floor, withdrew because of ill health and recommended the election of Horace W. Wilds, N. Y. 1, who in the ensuing election won over John Topham, Col. 2, by a vote of 135 to 72.

In a four sided contest, Buffalo, Pittsburgh, St. Louis and Cincinnati, Buffalo was chosen as the 1933 convention city on the second ballot by a vote of 114 to 94, having failed by 5 votes of receiving a majority on the first ballot. Cincinnati was eliminated by the convention committee and St. Louis, which received 36 votes on the first ballot, withdrew before the second ballot in favor of Pittsburgh. Buffalo gained strength, however, and in spite of the maneuver by the Missouri delegation won by a safe margin.

NATIONAL EXHIBITORS ASSOCIATION

On the same day the National Exhibitors Association elected the following officers: President, John H. Allen, Everlasting Valve Co.; Vice-president, G. C. Freeman, The Chicago Faucet Co.; Treasurer, Fred G. Jolley, Jenkins Bros.; Sec., F. N. Chapman, A. Leschen & Sons Rope Co.; Executive Committee, Bob Jones, Garratt-Callahan Co.; S. C. Smith, King Refractories Co.; Elmer W. Reitz, the Powers Reg. Co.; Homer L. Rank, The Strong-Scott Mfg. Co.; L. M. Reed, Bundy Steam Trap Co.

OTHER SOCIETIES

In addition to the N.A.P.E., a number of other societies held meetings, the principal ones being the Great Lakes Power Club, the fall meeting of the Engineering Section, Great Lakes Division of the N.E.L.A.; A.S.H. & V.E., Engineers Society of Milwaukee and the Society of Military Engineers. The combined gathering including the power show was arranged under the general title, Great Lakes Power Conference of which G. G. Post of The Milwaukee Elec. Ry. & Light Co. was chairman and J. A. Prudell, President of Wis. 1 (and later elected national vice-president of the N.A.P.E.) was vice-chairman.

Many of the meetings were business sessions or confidential committee meetings of interest only to the participating society. Three sessions were, however, of general interest. Before a joint meeting of the A.S.H. & V.E., University and College group, John Howatt, Chief Engineer, Board of Education, Chicago, discussed the selection and maintenance of heating and ventilating equipment for educational buildings from the background of a long and practical experience. At the same session, Ernest Szekely presented his views of the functions and responsibilities of the consulting engineer.

GENERAL SESSIONS

Perhaps the most interesting papers of the meeting from the power engineer's standpoint were two presented before the Power Club. The first by Grover Keeth of the Marathon Paper Co., discussed the question of power in the industrial plant using power steam and drew the conclusion that power can be purchased profitably in many cases. The second paper by J. S. McMullen, Northern States Power Co., Eau Claire, Wis., covered some first hand experiences of power salesmen with oil engines. Later E. W. Atkinson of the Public Service Co. of N. Ill., led an interesting discussion of air conditioning as a load building possibility for the power companies. At a joint evening session sponsored by the Engineers Society and the Society of Military Engineers, Major General Al Lytle Brown, Chief of Engineers, U. S. Army, outlined the position of engineers in public works with particular reference to the part being played by the army engineers in connection with the work of the R.F.C. One point of interest brought out by the discussion was that no allowance for financing municipal power stations had been made.

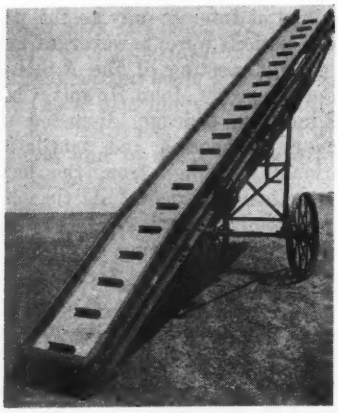
In addition to the technical programs and committee meeting a comprehensive program of inspection trips was arranged, including among others, Lakeside Station and all parts of the Milwaukee Elec. Ry. & Light Co. system; Riverside Pumping Station; International Harvester Co.; Pabst Corp.; and Phoenix Knitting Co. Mills.

THE ELECTRICAL input to the average electric motor used in electrical clocks is in the neighborhood of two watts, but as the power factor is low, the volt amperes will vary from 3 to 6. The efficiency of these motors is very low, amounting to a fraction of 1 per cent. The power unit, however, is so little (17 kw-hr. per year or approximately $1.00 worth) that this feature is of minor importance.

New Equipment

New Portable Conveyor

LINK BELT Co., Philadelphia, announces a new conveyor with steel retaining sides its entire length to prevent spilling and a foot end designed to keep material away from the return run of the belt. The foot end plate can be removed if desired to minimize labor in feeding and speed up loading. Features are a



belt 18 or 24 in. wide by 21-ft. centers, ball-bearing motor, pipe frame adjustable for discharge height, large, wide tread wheels, Alemite lubrication.

Flashlight Screw Driver

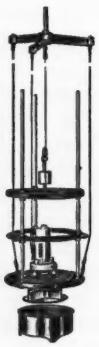
BY BUILDING a flashlight screw driver handle, Burgess Battery Co. delivers a definite spot of light on the screw, permitting the mechanic to use both hands effectively on his work.

Electrically, the handle has withstood test to 5200 volts. The makers recommend it for 110, 220, or 440-v. work.

Vibrationless Galvanometer Suspension

OF INTEREST to all who use Galvanometers is the new Galvanometer Suspension announced by the G-M Laboratories, Inc., 1731 Belmont Ave., Chicago. This unit, embodying many new refinements, is designed to provide a stable means of support for instruments of the suspended mirror type for all kinds of measurements.

This new Galvanometer Suspension fills a need among laboratories located in factories, along car tracks and railroads, or near buildings housing heavy engines and machinery. In such locations it has heretofore been virtually impossible to obtain stable galvanometer readings for accurate measurement, and many laboratories in such locations have been forced to make galvanometer measurements only at night. This new unit overcomes such difficulties, and even when attached to a ceiling which also supports heavy vibrating machinery, galvanometers of 1100 megohm sensitivity have a perfectly



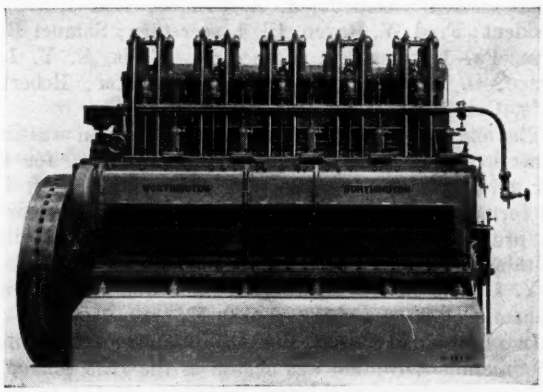
stable index line on a scale nine meters distant.

When correctly adjusted, vibrations transmitted to the supporting tripod travel down the three wires in phase and result only in a slight raising or lowering of the unit. The oil pan and vanes underneath the bottom plate in turn effectively damp vertical or lateral movements and prevent the suspension from being unduly affected by air currents or by touching the unit with the hands.

New Line of Diesel Engines

SALIENT FEATURES of construction of Diesel engines, from 50 to 1000 hp., in 2 to 8-cylinder units, four-cycle, direct-injection, moderate-speed, recently introduced by the Worthington Pump and Machinery Corp. are: individual fuel pumps for each cylinder with fuel lines of equal length, which hydraulically control the injection of fuel; individual air starting pilot valves to control the admission of starting air to each cylinder; spray valves, pressure actuated, no push rods or levers being used. In the larger engines, air inlet and exhaust valves are carried in removable and interchangeable cages, the exhaust-valve cages being water cooled, while, in the smaller engines, these valves (also interchangeable and adjustable) seat directly in the cylinder head and operate in removable bushings.

Lubricating oil is circulated and force fed to all bearings by an attached pump. Cooling is provided at all essential points, the flow in all jackets being so directed that high

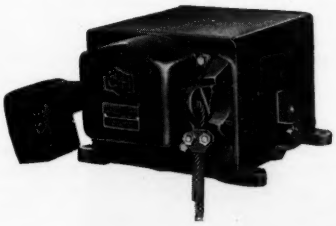


water velocities result and there are no dead pockets. Large handholes permit ready cleaning of the jackets of both cylinder liners and heads, and large doors in front and rear give unobstructed access to main and crank bearings. All of these Diesels can be easily converted to operation on manufactured or natural gas, fuel cams being omitted and a magneto and spark plugs replacing fuel pumps and spray valves.

FALK CORPORATION, Milwaukee, Wis., announces three styles of Motoreducers (combined motor and speed reducer) in which the gear housing acts as a support for the motor. In the Integral type the motor end bell is removed and the motor close coupled through a bayonet type of joint to the gear case. In the Flexible type the round frame type of motor is used and the end bell retained. In the All-Motor type any standard horizontal type motor may be used.

Small Crane Limit Stop

NEW SMALL SIZE crane limit safety stop, with standard mill type blowouts and contact tips, has been developed by Cutler-Hammer, Inc.,



Milwaukee, Wisconsin, to prevent over-travel of the hoist on electric cranes. Rated for 40 hp. and under, it takes only 9-in. head room. It is supplied with leads equipped with soldering lugs and cover removable for inspections and repairs.

New Unaflow for St. Bernard

Recently the Municipal Electric Light Plant, St. Bernard, Ohio, installed a 1000-kw. Ames vertical 18 by 20 in., 4 cylinder unaflow engine, direct connected to the 1000-kw., 3400-v. Allis-Chalmers generator, with 125 volt exciter, driven by a Texrope drive. The engine is equipped with Bowser lubricator, Lonergan gages and Irving walkways and stair treads.

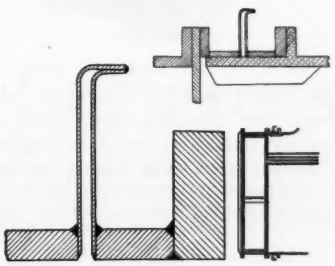
At the present time the engine is operating at 150-lb. steam pressure but has been designed to operate eventually at 250-lb. gage, 200 deg. superheat. This unusual operating condition was brought about due to the fact that the plant, originally designed many years ago, was intended for 150-lb. pressure. Two years ago it became necessary to replace one of the old boiler units. A definite program of expansion was decided upon and a new 550-hp. Stirling boiler with Westinghouse stoker was installed at that time. The unit is designed for 250-lb. pressure, 100 deg. superheat but at the present is operated at a pressure of 150-lb. because of the low pressure engines.

The second 550-hp. Stirling unit will soon be installed. At that time the boiler pressure will be increased to 250 lb. and the new Ames engine will carry the entire load, the older 150-lb. engines being kept for standby.

Specifications for and design of the new municipal plant made by Selden F. High, consulting engineer.

Welded Condenser Expansion Ring

IN A PAPER awarded a prize by the Lincoln Electric Co., Cleveland, O., in its Arc Welding prize competition, John Wambach, engineer in the condenser department of Allis-Chalmers Mfg. Co., describes a novel condenser construction to take care of the expansion of condenser tubes



that are expanded into the tube sheets to prevent leakage of raw water into the condensate. It is important to prevent such leakage especially where the use of high-pressure boilers requires feed water to be free from scale-forming solids and oxygen.

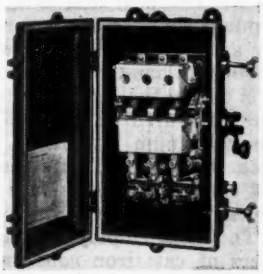
To take care of tube expansion, "bowing" of tubes, permitting the center portion to rise and fall with change of temperature has been used, also rubber expansion joints between condenser shell and tube sheet. The new method described by Mr. Wambach utilizes an arc-welded steel expansion ring as shown in the illustration, usually placed at one end of the shell and permitting horizontal motion of one tube sheet, without strain on the tube-end joints.

This ring is made up of two parallel sheets of steel, specially formed and with edges arc welded where they join. Free edges are welded to heavy steel rings and these in turn to flange rings which are bolted to condenser, tube sheet and water box flanges. The design is original, is possible only with the use of welding and has been applied in sizes up to 20 ft. diam. or 16 by 24 ft. oval.

Elimination of raw water leakage makes unnecessary the deaeration of condensate or its treatment for removal of scale-forming material, thus often reducing considerably the cost of equipment and operation.

Moisture-Proof Starter

A. C. COMBINATION starters, enclosed in a cast-iron cabinet having machined flanges and fitted with rubber gaskets to exclude moisture and dust, have been added to the



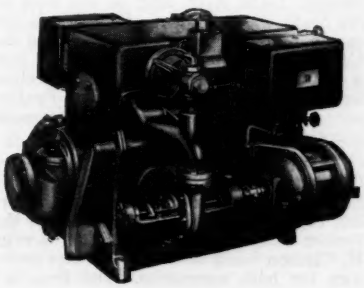
line manufactured by Industrial Controller Division, Square D Co., Milwaukee. The apparatus, which is not explosion proof, is intended for installation in damp or dusty locations and corrosive atmospheres such as found in flour mills, cement plants, packing plants and similar places. The unit consists of an across-the-line starter, motor control switch and test jack.

Improved Vacuum Pump

IN ANNOUNCING its redesigned line of Hoffman-Economy Vacuum Pumps, the Economy Pump Company of Waterbury, Conn., points out a number of improvements of interest to heating engineers and contractors.

By making a number of changes in pump designs new features have been incorporated which are based on long study of actual operating conditions. These, it is claimed, result in quietness and all-around ability to deliver maximum efficiency under severest conditions of service.

Tests made on a model DV6 Return Line Vacuum Pump indicate



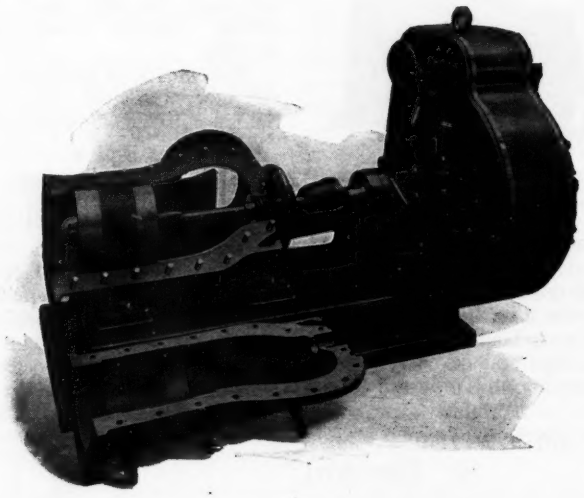
the following unusual capacity range: When starting a cold job, this pump records an air capacity of 160 per cent of rating. The flood of initial condensate reaching the pump after exhaustion of air, is removed at the rate of 300 per cent of rated capacity. Thereafter, the removal of air and water is accomplished simultaneously—a most important factor in efficient performance of vacuum pumps.

At 160 deg. water temperature and 6-in. vacuum, pump capacity for both air and water is 100 per cent. At 195 deg. and 3-in. vacuum, pump capacity is 85 per cent for air and 100 per cent for water. This ability to handle almost boiling water is due to the Jet-type vacuum producer featured in all Hoffman-Economy Vacuum Pumps.

Both vacuum and condensation pumps of this company have been simplified and improved in appearance. They now employ rectangular receivers of cast iron construction, sturdy and non-corrosive. Motors are of standard make, permitting quick replacement if necessary and all pump parts are readily accessible.

Propeller Pump

DE LAVAL propeller pump for handling relatively large volumes of liquid against comparatively low heads is built for horizontal or vertical installation, for all capacities and for heads up to about 40 ft. The pump casing consists of two parts, separated along the center line of the shaft by a flat joint, with thin paper gasket. Propeller, designed for specified conditions of capacity, head and speed, is finished on all surfaces. The casing around the propeller is protected by a renewable separate sleeve, which supports the guide vanes by which the liquid is directed in smooth flow-lines. At the coupling end, the shaft is supported by a grease-lubricated ball bearing with separate thrust bearing in the same housing. At the propeller end, it is supported by a sleeve bearing. The stuffing box is designed for soft packing, with a lantern ring to facilitate water sealing where desired, the gland being split for easy removal.



News From the Field

AT DIABLO DAM 83,000-hp. plant on the Skagit River, Washington, will be installed a 300-t., two-trolley traveling crane, with span 60½ ft., spread of 16 ft. and lift of 65 ft., weight 392,800 lb. For the main hoist, a 40-hp. motor, for the 25-t. hoist a like motor, for bridge operation 60-hp. and for trolley hoist 15 hp. will be used, all 3-phase for 220 v. and 60 cycles. It is stated by Harnischfeger Corp., the makers, to be the largest power house crane ever built.

RUSSELL H. BALLARD, president of the Southern California Edison Co. Ltd., and prominent in the hydroelectric industry for 25 yr., died of pneumonia in Los Angeles, Calif., Aug 2 at the age of 57. He was born in Hamilton, Ont., Can., had served as president of the Pacific Coast Light Assn. and of the National Electric Light Assn. and, at the time of his death was president of California Institute Associates, engaged in building the California Institute of Technology into a center for research. In this connection he was instrumental in bringing Professor Albert Einstein and other famous scientists to California.

WORTHINGTON Pump and Machinery Corp. and Gamon Meter Co. have arranged for joint use of the manufacturing, engineering and sales facilities of the former companies Meter Division, George H. Gleeson being in charge of sales activities for both companies. The lines are supplemental and cover disc, turbine, compound and piston meters for measuring all liquids.

GENERAL Refractories Co., Philadelphia, Pa., announces that an arrangement has been concluded with the McLeod & Henry Co., of Troy, N. Y., whereby it is offering to the trade the CARBEX commodities manufactured by the latter company.

NATIONAL Safety Council and American Society of Safety Engineers will hold their annual congress in Washington, D. C., Wardman Park and Shoreham hotels, Oct. 3 to 7. In the 120 sessions, marine safety and accident prevention will be prominent, also dust problems, electrical hazards, safety codes and an exhibit of modern safety equipment.

C. G. ONG, formerly Manager of the Small Turbine Department of the Westinghouse Co., is now selling Murray turbines for the Murray Iron Works Company of Burlington, Iowa, with headquarters at Room 1610—15 Park Row, New York City.

THE RILEY STOKER Corporation announces that Mr. George G. Van Tuyl has been appointed District Manager at the Cleveland, Ohio, office beginning September 1, 1932.

THE MERCON REGULATOR Company announces extensions to its line of flow controllers. The company has formerly manufactured constant flow regulators, flow limiting regulators, and proportioning regulators for the more general applications involving fluid mixing problems. The new line is broadened to include regulators for maintaining proportional flow of liquids where the two liquids do not mix or if mixing may do so at process points remote from the point of desired control.

NATIONAL ASSOCIATION of Practical Refrigerating Engineers will hold its twenty-third annual convention and educational exhibition at the Sherman Hotel, in Chicago, November 1 to 4 inclusive. There are more than 600 members in the Chicago Chapter of the N.A.P.R.E. alone and scores of chapters throughout the United States. Edwin S. Libby, Professor of Refrigeration at the Armour Institute of Technology, has arranged instructive programs by leading refrigerating engineers. Refrigerating and ice plant executives and their engineers are invited to attend and participate in the proceedings. For information regarding the convention, hotel and railroad rates, write Edward H. Fox, Secretary of the N.A.P.R.E., 435 No. Waller Ave., Chicago.

ROBERT L. SHERATON, New England representative of Hagan Corporation and Hall Laboratories, died suddenly at his home, Newtonville, Mass., on Sept. 2. He was born in St. John, N. B., his parents being Alfred and Mary Sheraton. He

graduated from King's College at that time located at Windsor, N. S., later taking a degree at McGill College in Montreal. Mr. Sheraton was a member of Commonwealth Country Club and of Boston Athletic Assn. and was prominent in Masonic activities, Commandery, Scottish Rite and Mystic Shrine. He was also active in the conduct of St. John's Episcopal Church of which he was a member and vestryman. He is survived by his wife, Edna L. Sheraton, a son, Robert J. and a daughter, Kean Lawton.

CANADIAN GOVERNMENT has issued an order-in-council approving plans for development of 500,000 hp. at the Beauharnois project near Montreal so that 35,000 hp. will be delivered to Ontario Hydro Electric Power Commission, beginning Oct. 1, to be increased to 250,000 hp. at the end of 5 yr. A 14-mi. canal, 27 ft. deep between lakes St. Louis and St. Francis will form part of the St. Lawrence waterway development.

THOMAS M. JONES has been appointed general sales manager of Keystone Lubricating Co., Philadelphia, Pa. Mr. Jones has been active for 14 yr. as advertising counselor and merchandising advisor and will give his attention to developing and extending the company's distributor plan.

CENTRIFIX CORPORATION, Cleveland, Ohio, manufacturers of purifying equipment for steam, vapor, gas and air, announces the appointment of a New York sales representative, Parry Engineering Co., 3216 Chrysler Building, the personnel of which includes H. L. Parry, W. F. Wurster and F. K. Howell.

S. A. HADLEY, 609 Interstate Building, Kansas City, Missouri, has been appointed sales representative in the Kansas City territory for boilers, engines, turbines, reduction gears and unit heaters by the Murray Iron Works Company of Burlington, Iowa.

M. SCHILLER, in addition to his duties as vice president of The Superheater Co., of New York and Chicago, has been elected treasurer to succeed W. F. Jetter, recently resigned. F. J. Dolan was elected assistant secretary and assistant treasurer of the company. Mr. Thos. F. Morris was elected treasurer and assistant secretary of The Superheater Co., Ltd., of Montreal, to succeed W. F. Jetter, who resigned.

ANNOUNCEMENT is made by the Harnischfeger Corporation, Milwaukee, of its recent acquisition of the manufacturing rights for the entire line of Northwestern motors and generators formerly produced by the Northwestern Manufacturing Co. of Milwaukee, in capacities from ½ to 150 hp. of types for all current characteristics. Important changes and additions to the line are planned by the Harnischfeger engineers.

Another acquisition is manufacturing rights for the Hansen Arc Welder, developed by the Northwestern Manufacturing Co., with Klaus L. Hansen, inventor, joining the staff of the Harnischfeger Corp. which has recently entered the welding field with a line of welding fixtures, known as Position Finders, to handle and hold heavy parts at such angles as to permit 45-deg. welding necessary for strong welds.

LOUIS E. UNDERWOOD, managing engineer of the stationary motor engineering department of the General Electric Company at Lynn, Mass., has been appointed manager of the Pittsfield, Mass., works of the company to succeed E. A. Wagner, who has retired, it has been announced by Vice President W. R. Burrows, in charge of manufacturing.

For the Engineer's Library

MAC'S Coal Directory and Buyers' Guide, 1932 edition is now offered by Coal Information Bureau, Union Trust Bldg., Pittsburgh, Pa., at a price of $10 a copy. It gives information on coal-selling companies, their branches and executives, on coal operating companies, mines, equipment, and purchasing offices, on coal trade names and leading coal-originating railroads.

REFRACTORIES MANUAL is the title of a 94-page publication issued by the American Society for Testing Materials, 1350 Spruce St., Philadelphia, Pa. Price, $0.50. This booklet brings together in convenient form standard specifications, methods of tests, and definitions pertaining to refractories, and contains in addition a manual, prepared by Committee C-8 of the society, for the interpretation of refractories test data,

FORD ENGINED Ready-Power Electric plants, of the Ready-Power Co., Detroit, Mich., are described and illustrated in its bulletin No. 61 in size of 7½ kw., self-cooled or marine type for 32, 115 and 230 v. direct current and for 110,220 and 440 v. single or 3-phase alternating current.

SINGLE-STAGE Turbo-Blowers as made by Allis-Chalmers Mfg. Co., Milwaukee, Wisc., are shown in its bulletin No. 1908. Construction, performance curves and applications are described and illustrated.

BULLETIN CA-202, describing its new Type C and General Service lines of industrial switches is issued by Square D. Co., Detroit, Mich.

ELECTRIC RANGE sales plan book is sent out by N.E.L.A., 420 Lexington Ave., New York City, to assist in campaigns for furthering the use of electric cooking. Various ways of organizing a sales campaign, suggestions for advertising and demonstrations are included. The National Electric Cookery Council at the same address is prepared to render assistance in the work.

MULTISTAGE centrifugal pumps with single suction impellers are described in Catalog B-5, distributed by the De Laval Steam Turbine Co., Trenton, N. J. These pumps are built with as many as seven stages in one casing and for heads up to or exceeding 1600 lb. per sq. in. Horizontally split casings with one piece diaphragms, labyrinth wearing rings and a hydraulic system for taking care of axial thrust are features. These pumps are built both with and without diffusion vanes and in special designs for handling high temperature fluids.

BULLETIN No. 36 has just been issued by Baldwin-Southwark Corporation, Philadelphia, covering their line of high-pressure hydraulic pumps both horizontal and vertical. A detail description of the construction of these pumps together with tables of dimensions and capacities is included. A page is devoted to a description of high-pressure hand pumps and another page to that of the new hydrogas accumulator hydraulic power system—a system which retains all the conveniences of the weighted accumulator and adds several advantages of its own.

G-R STORAGE tank oil heater is described in a leaflet issued by Griscom-Russell Co., 285 Madison Ave., New York, N. Y.

GENERAL ELECTRIC Oil Furnace is the title of a 12-p. bulletin giving the advantages of the new combined boiler, hot water heater and oil burner introduced by General Electric Co., Schenectady, N. Y.

SELLING Better Lighting in the Home and How to Sell More Portable Lamps are the titles of bulletins Nos. 1 and 2 issued by National Electric Light Assn., 420 Lexington Ave., New York City, in a campaign for increasing lighting load. Copies can be had at 25c each in lots of 1 to 10 and lower for larger quantities.

PROFITS from Stoker Firing, 3rd edition, is being distributed by Modern Coal Burner Co., 3733 No. Lincoln Ave., Chicago, Ill., describing the action of its underfeed screw stoker and showing details of construction.

RECIRCULATION and filtering of water for swimming pools by the Cochrane filter is described in publication No. 1782, recently issued by the Cochrane Corporation, Philadelphia, Pa. By turning the handle of the single control valve to the proper positions in sequence, the filter is cut out of service, backwashed, washed to waste and restored to service.

STOP WASTE WITH Regulatair, is the title of a 16 page booklet recently issued by the Automatic Combustion Regulatair Systems, 165 E. Superior St., Chicago.

FUNDAMENTALS OF INSTRUMENTATION. By M. F. Behar. Published by Instruments Publishing Co., 3619 Forbes St., Pittsburgh, Pa. 109 p. 6 by 9 in., cloth. Price $2.00.

Part I of a complete series of seven handbooks covering the complete field of engineering. Several of the other sections have appeared or are now appearing serially in the magazine Instruments. The first chapter of this volume deals with the definition of terms and classification of instrument needs, the second deals with the properties and characteristics of industrial instruments and the third with the extremely important subject of automatic controllers. The fourth and last chapter, perhaps the most practical for the industrial engineer, consists of seven articles by different authors setting forth the personnel, location, function and operation of an instrument department for an industrial plant.

Power Plant Construction News

Ariz., Nogales—City Council is considering installation of a municipal electric light and power plant. Initial unit is reported to cost over $40,000, with equipment, and will be increased in near future.

Ark., Conway—City Corporation Board has authorized plans for extension and improvements in municipal electric light and power plant, estimated to cost over $45,000, with equipment. J. J. Hiegel and Guy R. Farris are head of building committee, in charge.

Ark., Paragould—City Council has authorized a special election on October 24, to approve funds for $100,000, appropriation to be used for construction of a municipal electric light and power plant. Plans will soon be completed.

Calif., Los Angeles—Pacific Carbonic Co., care of T. F. Pattison, manager, R. F. D. No. 2, P. O. Box 143, Orange, Calif. (recently organized by Mr. Pattison and associates), plans installation of electric power equipment in proposed dry ice-manufacturing plant on Terminal Island, Los Angeles Harbor, entire project to cost close to $200,000.

Colo., Fort Collins—City Council, A. J. Rosenow, city clerk, is arranging a special election to approve bonds for $745,000 for construction and operation of a municipal electric light and power plant. Plans will soon be drawn. Burgis C. Coy, Fort Collins, is consulting engineer.

D. C., Washington—Potomac Electric Power Co., Washington, is completing plans and will soon begin construction of a steam-operated electric power plant at Buzzard's Point, junction of the Potomac and Anacostia Rivers. Initial unit will be equipped for capacity of 35,000 kw., to be increased to about 200,000 kw. at later date. Entire project will cost over $3,500,000, with transmission lines. Stone & Webster Engineering Co., 49 Federal Street, Boston, Mass., is engineer.

Ind., Lawrenceburg—Rossville Commercial Alcohol Co., Lawrenceburg, plans installation of electric power equipment in connection with proposed rebuilding of portion of plant, recently destroyed by fire. Loss about $100,000. Headquarters are at 122 East Forty-second Street, New York.

Iowa, Atlantic—City Council has plans nearing completion for extensions and improvements in municipal electric light and power plant, estimated to cost about $100,000. Also proposed to construct electric distributing system to cost about $25,000. Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., is consulting engineer. Expect to ask bids in near future.

Iowa, Sioux City—City Council is said to be arranging a special election to approve bond issue of $3,500,000, for a proposed municipal electric light and power plant. Edgar V. Moone is city clerk. City engineer will be in charge of project.

Kan., Coffeyville—Sinclair Refining Co., 45 Nassau Street, New York, N. Y., a subsidiary of Consolidated Oil Corporation, same address, plans installation of power equipment, pumping machinery, tanks and other mechanical equipment in connection with an expansion and improvement program at oil refineries at Coffeyville and Argentine, Kan., entire project to cost $2,000,000. Company engineering department will be in charge.

Kan., Wichita—Derby Oil Co., 358 North Lawrence Street, plans extensions in power department at oil plant, including installation of boilers, pumping equipment, reducing turbines and accessory equipment. Entire project estimated to cost over $100,000. A. B. Hungerford, address noted, is company engineer.

Ky., Lexington—Board of City Commissioners plans installation of pumping machinery and auxiliary equipment in connection with new sewage treatment plant and sewage system. Entire project estimated to cost over $1,000,000. Fuller & McClintock, 170 Broadway, New York, are consulting engineers.

Md., Illchester—Susquehanna Transmission Co., Lexington Building, Baltimore, Md., a subsidiary of Pennsylvania Water & Power Co., same address, has secured permission to construct a 22-mile steel tower transmission line from Illchester to point near District of Columbia, to operate at 220,000 volts. A large switching station will be constructed near Ellicott City, Md. Entire project will cost over $300,000. Company engineering department in charge.

Mass., Charlestown—Bureau of Yards and Docks, Navy Department, Washington, D. C., has preliminary plans under consideration for extensions and improvements in power plant at navy yard, Charlestown, estimated to cost about $100,000, with equipment. Proposed to ask bids at later date.

Mass., Hudson—Municipal Light and Power Department, Town Hall, has approved plans for immediate construction of a one-story addition to municipal electric light and power plant, 40 x 108 ft., reported to cost over $75,000, with equipment.

Minn., Elk River—Village Council, W. F. Chadbourn, Village clerk, has authorized surveys for a proposed municipal electric light and power plant. Estimated cost about $85,000, with equipment. Ralph W. Richardson, New York Life Building, St. Paul, Minn., is consulting engineer.

Minn., St. Paul—Advisory City Hall and Court House Building Commission, Carl P. Herbert, Athletic Club, executive secretary, has submitted report to City Council recommending construction of an electric light and power plant for service at new City Hall and Court House. Estimated cost about $225,000, with equipment.

Neb., Ainsworth—City Council has authorized immediate preparation of plans for proposed municipal electric light and power plant, and has selected Burns & McDonnell Engineering Co., Interstate Building, Kansas City, Mo., as consulting engineer for project. Installation is estimated to cost $84,800 with equipment.

N. Y., Albany—Co-Operative Grange League Federation, State Tower Building, Syracuse, N. Y., plans installation of electric power equipment, hoisting, conveying and other mechanical equipment in new five-story feed mill on waterfront site at Albany, entire project to cost over $100,000.

N. Y., New York—New Amsterdam Brewing Co., 10 East Fortieth Street, recently organized by Herbert L. Noll (president) and associates, plans construction of a power house at proposed new brewing plant in vicinity of city. Entire project will cost close to $2,000,000. Machinery in plant will be electric-operated.

N. C., Thomasville—Boyle Veneer Mill plans installation of electric power equipment in connection with rebuilding of portion of plant, recently destroyed by fire with loss estimated over $100,000.

Ohio, Cincinnati—Cincinnati Rubber Mfg. Co., Bond Hill district, has plans nearing completion for extensions and betterments in power plant, with installation of generator unit, boilers, coal and ash-handling equipment and accessories. Estimated cost over $75,000. A. M. Kinney, Inc., Carew Tower, is architect.

Ohio, Conneaut—Department of Public Service, G. F. McKenzie, director, plans construction of an electric-operated pumping plant in connection with new municipal waterworks. A filtration plant will also be installed. Entire project is estimated to cost about $250,000. Arrangements to secure funds now under way.

Ohio, New Lexington—City Council is considering installation of an electric light and power plant, and will have estimates of cost made at early date. Walter Graf, Lancaster, Ohio, is consulting engineer.

Okla., Oklahoma City—Evans Pure Milk & Ice Cream Co., Oklahoma City, has plans under way for a new ice-manufacturing and ice cream plant at Broadway and Twenty-second Street, one and two-story, cost about $50,000, with equipment. Schumacher & Winkler, First National Bank Building, are architects.

Pa., Farrell—City Council, Farrell, plans installation of pumping machinery and auxiliary power equipment in proposed municipal waterworks. Entire project estimated to cost about $400,000. Mayor J. A. Franek is interested in improvement.

Pa., Nemacolin—Youngstown Sheet & Tube Co., Youngstown, Ohio, plans installation of electric power equipment, hoisting and conveying, and other mechanical equipment in new coal tipple and loading dock at coal-mining properties at Nemacolin, entire project to cost about $150,000.

S. D., Canton—City Council has authorized surveys for a proposed municipal electric light and power plant. Estimated cost over $100,000. Buell & Winter, Insurance Exchange Building, Sioux City, Iowa, are consulting engineers.

Texas, Pilot Point—Texas-Louisiana Power Co., Fort Worth, Texas, is planning rebuilding of portion of power plant at Pilot Point, recently destroyed by fire with loss reported at $45,000, including equipment.

Wash., Brinnon—Washington Electric Co., Stuart Building, Seattle, Wash., has tentative plans for a new hydroelectric generating plant on Dosewa'lips River, near Brinnon, with power dam 208 ft. high and 400 ft. long. Project is reported to cost about $1,500,000, including transmission system.

W. Va., Weirton—National Steel Corporation plans installation of heavy duty and other electric power equipment in connection with an expansion and improvement program at local mill, for which a fund of over $700,000 has been authorized.

Wis., Cassville—Village Council plans construction of a pumping plant in connection with new sewage disposal plant and system. Estimated cost about $35,000. Bids will soon be asked. W. G. Kirchoffer, 22 North Carroll Street, Madison.